

THE BULLETIN



OF THE ATOMIC SCIENTISTS

MAY 1993 \$3.00

SOVIET
SPIES,
BOMBS,
AND
YULI
KHARITON



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THE BULLETIN

OF THE ATOMIC SCIENTISTS



The *Bulletin* was founded in 1945 by Eugene Rabinowitch and Hyman Goldsmith.
The *Bulletin* clock, symbol of the threat of global catastrophe, stands at 17 minutes to midnight.

ARTICLES

Remembering Bernie

Albert Wattenberg, Joseph Rotblat, and Kosta Tsipis fondly recall
Bernard T. Feld, a Manhattan Project scientist,
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DAVID HOLLOWAY

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YULI KHARITON & YURI SMIRNOV

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ROALD SAGDEEV

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Reasons of state

Yuli Khariton—a pivotal figure in the Soviet Union's nuclear weapons program—has been speaking out lately in an attempt to set the record straight regarding the early years of the program. A speech he and Yuri Smirnov made in January at the Kurchatov Institute in Moscow struck us as an important historical record, and we present nearly all of it in this issue, beginning on page 18. David Holloway of Stanford helped greatly with the translation, and in putting the Khariton/Smirnov speech in perspective.

Meanwhile, Roald Sagdeev, a former Soviet scientist who now lives and works in the United States, weighed in with a piece on how Khariton helped suppress an attempt to publish KGB files that would have illuminated the role that spies played in the early days of the Soviet nuclear program. (Khariton said the documents might have been useful to today's would-be proliferators.)

Finally, Sergei Leskov, a science reporter at *Izvestia* and a current *Bulletin* Fellow, suggests that Khariton may have helped suppress publication of the documents, at least in part, in an effort to protect his own towering reputation. In any event, Sergei argues, it's all moot. Many copies of the journal that printed the documents were distributed before the issue was suppressed. If a spy wants the American bomb secrets obtained by the KGB, all he needs to do is locate a copy of *Issues in the History and Methods of Natural Science*.

Walter Lippmann said "the tempo of history is hard to judge correctly." Just so. Everything about history is hard to judge. That's what makes it so endlessly fascinating to scholars—and so useful to anyone who takes the world seriously. If we are to understand where we are today, we must understand where we have been. That's a hoary truism, of course, but the truth of it sometimes gets lost in these go-go cellular-phone times. In any event, I suspect that you'll find the Holloway-Khariton-Smirnov-Sagdeev-Leskov material intriguing.

Another truism: History is written by the victors. Or, in Linda Rothstein's variant, by those who live the longest—a category that embraces Khariton, who is nearly 90. At one point in his January speech, for instance, Khariton discusses the intense patriotic fervor that animated the scientists working at the super-secret bomb lab, Arzamas-16. To be sure, he adds, "there was little joy in watching the columns of prisoners who built the installation initially." But that unpleasantness "receded into the background" as the scientists "carried out their task splendidly."

Did you feel a chill? Linda, the *Bulletin's* managing editor, did. She recalled that Andrei Sakharov, another key member of the Soviet bomb team, had expressed a bit more ambivalence about the prisoner thing in his *Memoirs*. Yes, says Sakharov, the scientists were energized by the urgency of the task. In their own way, they were defending the Motherland. But they were not unaware of the casual brutality of the Soviet system. Shortly before he joined the lab, he writes, a group of prisoners building the installation rebelled, killing some guards. They fled to nearby forests and villages, but they were quickly wiped out, to a man, by NKVD troops. Sakharov suspected that many prisoners who did not join the rebellion were also executed.

Another tale told by Sakharov involves a luckless diver. A trolley carrying "hot" uranium slugs derailed in a water-filled pool under a production reactor. Rather than shut down the reactor so that the problem could be fixed safely, albeit at a substantial loss in plutonium production, a diver was ordered into the pool to repair the damage. The diver received a fatal dose of radiation, and he was buried in the installation's cemetery. "In accordance with nautical tradition," notes Sakharov, "a bronze anchor was erected over his grave."

History teaches many lessons, not the least of which is that many crimes, large and small, are committed by reasons of state.

—Mike Moore

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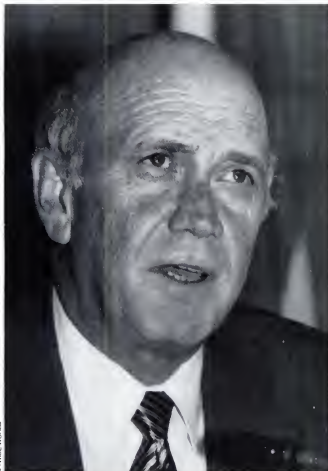
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AP/WIDE WORLD

President F. W. de Klerk said South Africa had developed "nuclear devices," then dismantled and destroyed them.

South Africa comes clean

South African President F. W. de Klerk made headlines on March 24, when he admitted to a joint session of parliament that South Africa had once had a supply of nuclear weapons; six of seven planned devices had been completed. South African spokesmen had previously said that Pretoria was capable of building weapons but they had remained deliberately vague about whether it had built any.

According to de Klerk,

the weapons were dismantled and their weapon-grade uranium-metal cores melted down and re-cast before South Africa signed the Nuclear Non-Proliferation Treaty (NPT) on July 10, 1991.

De Klerk's revelations came in response to charges by both the African National Congress and U.S. government officials that South Africa had possibly hidden atomic bomb components and manufacturing plants, and that it had been evasive

about its stockpile of weapon-grade uranium (April 1993 *Bulletin*). To counter these charges—and to bolster its international image—the South African government decided to divulge more information on its past nuclear program, even though the NPT does not require it to do so.

President de Klerk invited the International Atomic Energy Agency (IAEA) to send inspectors to the facilities where weapons work had been performed and to review some of the records of those sites.

According to de Klerk, the decision to build nuclear weapons was "taken as early as 1974, against the background of a Soviet expansionist threat in South Africa." The buildup of Cuban forces in Angola after 1975 reinforced South Africa's perception that a nuclear deterrent was necessary. And South Africa's increasing international isolation added to its fear that it could not rely on outside assistance in the event of an attack.

As a result, South Africa wanted a "limited deterrent capability." According to de Klerk, "The strategy was that, if the situation in southern Africa were to deteriorate seriously, a confidential indication of the deterrent capability would be given to one or more of the major powers, for example the United States, in an attempt to persuade them to intervene."

The program's objective was to produce seven nuclear fission devices, a number "considered the minimum for testing purposes and for the maintenance thereafter of a credible deterrent capability." De Klerk did not explain why seven weapons were sufficient.

The first device was completed in 1980. When the

program was terminated in early 1990, only six devices had been completed. De Klerk said that South Africa had not developed thermonuclear weapons.

The nuclear device used a "gun-type" design, weighed about one ton, and had a diameter of nearly 65 centimeters and a length of about 1.8 meters. Its yield was roughly 10 to 18 kilotons, but it was never verified by a nuclear test. The device was too large for delivery by artillery, and it was apparently intended to be dropped from British-supplied Buccaneer bombers.

The program was controlled directly by the head of government, who decided that Armscor, a company that has been privatized and is now called Denel, would manage and implement the weapons program. South Africa's Atomic Energy Corporation (AEC) evaluated portions of the early weapons design at its facilities, which include Pelindaba. Only a few cabinet members knew about the program. Armscor developed and produced the nuclear devices at its Advena Central Laboratory, 15 kilometers east of Pelindaba. Advena served as a smaller version of the U.S. Y-12 and Pantex plants.

By late 1988, both international and domestic

"They're the K-Mart of weapons manufacturers."

—Treasury Department spokesman describing the Chinese army's sales of guns in the United States, Washington Post, March 4, 1993.

In brief

■ Pushing the button

The Titan Missile Museum is in the desert south of Tucson. Tourists visit an underground bunker where a missile crew once stood ready to push the button. Pairs of visitors are encouraged to take turns sitting at the control panels to simultaneously turn the nuclear keys to initiate a simulated launch of a hydrogen bomb-carrying Titan II missile. The museum, which opened in 1986, has provided guided tours for about 300,000 visitors, who are also treated to a film that pays tribute to the missile's manufacturers—Martin Marietta, Aerojet General, and General Motors (Jon Wiener, *Nation*, March 15, 1993).

■ My kingdom for a radio

After Hurricane Andrew struck the Miami area, the city manager of Homestead, Florida, asked the Federal Emergency Management Agency (FEMA) for 100 hand-held two-way radios because the town was left with only one working telephone. According to the *Washington Times* (February 22, 1993), FEMA, which spends \$12 on secret nuclear disaster programs for every dollar it spends on responding to natural disasters, apparently couldn't come up with the radios. Instead, Homestead got some high-tech vans that were designed to transmit encrypted, multifrequency radio messages to military aircraft.

■ Ten-hut, war lovers

Douglas Keeney of Louisville, Kentucky, thinks he has a winning idea for a special cable TV channel. Keeney and Lt. Col. Steve Titunik, who left the Pentagon to join the operation, plan to launch the 24-hour-a-day "Military Channel" next year (*Wall Street Journal*, March 11, 1993). Although the backbone of the channel's programming will be old war movies, Titunik is also developing new programs. He believes, for instance, that American men would prefer a televised exercise program "with the troops" to one led by a spandex-clad model. He is also working on a program featuring military cooking. But the money show may be a Home Shopping Network-type program that will hawk military paraphernalia. Keeney believes that the country is bursting with "war junkies." War, he says, is a big part of show business. "World War II is now more popular in the ratings than it's ever been in history."

■ The 11 percent solution

One of the benefits of the end of the Cold War, according to former Director of Central Intelligence Robert Gates and others, was going to be greater openness—well, sort of. According to the Information Security Oversight Office, government workers classified 6.3 million documents last year, for a whopping 11 percent reduction from the previous year (Associated Press, March 8, 1993).

changes had made the nuclear deterrent "not only superfluous, but in fact an obstacle to the development of South Africa's international relations," de Klerk told parliament.

The greatest of these changes was probably a tripartite agreement signed by South Africa, Cuba, and Angola on December 22, 1988, which brought Namibian independence and led to the withdrawal of 50,000 Cuban troops from Angola.

Soon after the cease-fire in Angola came the end of the Cold War. By late 1989 the government decided to close the Y Plant, where weapon-grade uranium had been produced, and the plant was closed in February 1990. The final-step equipment that enriched uranium to bomb-grade was dismantled and removed, according to a South African nuclear official.

In early 1990 the government also decided to dismantle and destroy its nuclear weapons and to return all the nuclear material in Armscor's possession to South Africa's AEC. Armscor's facilities were decontaminated and dedicated to non-nuclear commercial purposes.

Dismantling took place under the joint control of the AEC and Armscor, with independent oversight by a professor of nuclear physics, W. L. Mouton. The process involved accounting for all the nuclear material and destroying all available technical weapons-design documents, drawings, computer software, and other data.

On October 30, 1991, in accordance with its NPT commitments, South Africa gave the IAEA an inventory of all its nuclear materials and all the facilities that contained such materials as of September 30, 1991. In his speech, de Klerk invited the IAEA to inspect the "facilities and records of fa-

cilities which in the past were used for the preparation of a nuclear deterrent capability."

On March 25, three IAEA inspectors toured the Advena facility. They visited nuclear material casting and machining workshops, high-security vaults, high-explosive test cells, and an environmental testing facility.

The inspectors were told by facility personnel that all the specialized equipment used in the nuclear weapons program had been removed and destroyed, and that the casting and machining workshops had been fully dismantled. Documentation related to dismantling and accountability records had not been destroyed and were made available to the inspectors. Comprehensive follow-up inspections are planned.

De Klerk sought to allay concern that South Africa had cooperated with Israel on nuclear weapons. Although he did not mention Israel by name, he said that at "no time did South Africa acquire nuclear weapons technology or materials from another country, nor has it provided any to any other country, or cooperated with another country in this regard."

De Klerk also said that "South Africa has never conducted a clandestine nuclear test." Press spokespersons for the AEC and Armscor added that South Africa has never been involved in another country's nuclear test. South Africa was prepared to conduct a demonstration test, however. In 1987, at a test site in the Kalahari desert, one of two shafts—each about 200 meters deep and one meter in diameter—was reopened, inspected, and a hangar erected over it for easy maintenance in case a decision was made to conduct

an underground test.

Many questions remain unanswered. De Klerk did not say how much weapon-grade uranium South Africa had produced. Seven crude gun-type weapons would require a total of roughly 250–350 kilograms of weapon-grade uranium. And South Africa would probably have produced more, to fill and maintain a weapons manufacturing “pipeline,” or to maintain a strategic reserve.

Even more mystifying is

the question of whether and how South Africa intended to build a nuclear warhead suitable for a missile, something it was thinking about doing, according to a South African official. The gun-type design would likely have been too crude for delivery by missile.

Despite the many unanswered questions, de Klerk has taken a major step toward making the South African nuclear program more transparent.

—David Albright

15 years ago in the *Bulletin*

In the May 1978 *Bulletin*, Carter Henderson, co-director of the Princeton Center for Alternative Futures, Inc., argued that there was a growing movement among Americans to voluntarily simplify their lives.

He called it “the frugality phenomenon,” and he suggested that the trend, which began during the flowering of the 1960s counterculture, was spurred by the 1972 publication of *Limits of Growth*. This study, conducted by the Massachusetts Institute of Technology for the Club of Rome, concluded that the world economy was doomed to collapse “if the present growth trends in world population, industrialism, pollution, food production, and resource depletion continue unchanged.”

Similar studies predicted economic and emotional problems if economic growth was unceasingly pursued. Of these studies, Henderson found one prepared by Stanford University for the U.S. Environmental Protection Agency especially fascinating.

“Particularly interesting was its overall pessimism—seven out of [its] ten scenarios indicated a severe deterioration of the U.S. economy over the next quarter century, and it concluded the more Americans living frugal lifestyles, the better chance the U.S. economy will have to weather the economic storms ahead.”

Meanwhile, researchers from Montreal and McGill Universities in Canada had developed five possible future scenarios: the Status Quo (doing more with more); Growth with Conservation (doing more with less); a High-Level Stable State (doing the same with less); Buddhist (doing less with less); and the Squander Society (doing less with more).

“What seems to be happening in the market-oriented democracies,” Henderson wrote, “is that a ‘counter-economy,’ more interested in psychic than material income, is taking firm root.” He called this trend a growing “New Age” movement. “But whether the frugality phenomenon represents a fundamental shift in Western economic attitudes . . . remains to be seen.”

The base-closure waltz

A desire to protect bases and weapons contracts in their respective districts and states unites almost all members of Congress—Democrats and Republicans, liberals and conservatives, hawks and doves. Their unity was no more evident than in the latest round of proposed base closures—the third in five years.

In 1988 and 1991, there was a great hue and cry as the Pentagon closed a number of military posts. Now, virtually everyone concedes that the military budget will continue to shrink; however, that knowledge has not changed the walking or the maneuvering.

On March 12, Defense Secretary Les Aspin announced plans to close 31 major domestic military bases and to scale back operations at another 134 facilities. The Pentagon esti-

mates that these cutbacks will eventually save \$3.1 billion annually, although most of these savings would not come for many years.

Aspin's list is by no means final. The Defense Base Closure and Realignment Commission, headed by former New Jersey Republican Cong. James Courter, will review the inventory; the commission has the authority to add new bases or delete some bases already on the list. The entire package goes to the president by July 1; he can only accept or reject it in its entirety. Congress also has to agree that all or none of the bases will close; it can't modify the list.

Cries of anguish came from all quarters when Aspin's list was unveiled. Protests focused not on the vital need the bases served,



"I'm looking for the kind of suit a high-ranking civilian would wear."

Corrections

The April 1993 issue of the *Bulletin* contained two articles about "Team B," an exercise in competitive threat assessment conducted in 1976 to challenge the National Intelligence Estimates of Soviet military power and political intentions. In a photo caption, John Foster, Jr., was identified as a member of Team B. He was not; he was a member of the President's Foreign Intelligence Advisory Board, the group that recommended that the Team B experiment be conducted.

The January/February 1993 issue of the *Bulletin* contained a letter from physicist Hans Bethe on Germany's World War II nuclear program. Because of an editing error, the *Bulletin* garbled a reference to the enrichment of uranium for modern nuclear power reactors. The sentence should have read: "Water is used in modern power reactors, but the uranium is enriched to 3-4 percent."

The *Bulletin* regrets both errors.

but rather on the economic calamities that would be left in the wake of the closings. Shutting down the naval base in Charleston, said South Carolina Sen. Ernest Hollings, a Democrat, would be "an economic disaster." Connecticut Democratic Sen. Joseph Lieberman argued against eliminating the Groton submarine base: "This is a part of our state that is in a recession now. If the sub base is closed, it will go into a depression."

California's Sen. Dianne Feinstein a Democrat, facing reelection in two years, and an aggressive protector of California's interests, said, "I understand our country's military needs to reflect the realities of the post-Cold War world. But closing 10 bases in a state where the economy is still fragile and 1.5 million people are unemployed just doesn't make sense." Along with several other senators, Feinstein introduced a resolution arguing that the base closure commission should pay more attention to the economic impact closings will have on affected communities.

Feinstein argued with some justification that California would bear a disproportionate share of the pain. She produced statistics indicating that if all the California bases on the preliminary list (later modified) had been shuttered, the state would have lost more than 77,000 military and civilian jobs, representing a loss of \$6.4 billion in annual economic activity. And she advocated a massive conversion adjustment program to help the communities affected.

House Armed Services Committee Chairman Ron Dellums, another Democrat, joined the lobbying effort to protect California. He charged that it was "no coincidence" that five facilities in and near his Oakland district would close. He accused the military of retaliating for his 22 years of opposing their pet projects. According to the March 10, 1993, *New York Times*, Dellums proposed that these navy berths could become home to three nuclear carriers and provide housing and hospital beds.

In fairness, these politicians are doing what they

were elected to do: defend the interests of constituents whose livelihoods are threatened. Even Sen. Phil Gramm, a Texas Republican and chief deficit hawk, takes time out from his diatribes against federal spending to defend Texas-based, super-expensive projects such as the superconducting supercollider and the space station. He has no sarcastic words for federal funds spent on weapons produced in his state.

Occasionally, a politician will courageously promote the national interest despite cries from constituents. One such exception is Maine's Cong. Tom Andrews, a Democrat, who accepted the closing of Loring Air Force Base with great equanimity and argued for quickly planning for the future—much to the annoyance of Sen. George Mitchell, his very senior Democratic colleague, as well as Republicans around the state. Another exception has been

North Dakota's Byron Dorgan, a Democrat, who opposed deploying an anti-missile system and the MX rail garrison in his state despite pressure from local chambers of commerce. These few gutsy politicians argue that it is time to plan carefully to convert the economy from defense-dependent to non-defense-dependent industries and firms. In the long run, they say, each of their state economies will be stronger if it is no longer dependent on the military dole.

Yet to a Seawolf submarine worker in Connecticut or a restaurant waiter near San Francisco's Alameda Naval Station, the long-run benefits to the economy will come too late to save them from unemployment. Conversion assistance to help these workers and communities is essential to make the bitter pill easier to swallow.

—John Isaacs

Making hay bashing gays

President Bill Clinton's determination to end the ban on gays and lesbians serving in the military appears to have provided the religious right with a financial bonanza—and more. As Craig Shirley, a conservative consultant said, "It's great to have an enemy" (*Washington Times*, March 1, 1993). Those asking for contributions to "fight to keep the ban" include the Rev. Pat Robertson and the Rev. Jerry Falwell. According to the *Washington Times* story, Falwell believes that the

donations he receives may allow him to revive his defunct organization, the Moral Majority. Conservative groups are also using the "gays in the military" issue to raise funds. One of the groups is headed by Marine Lt. Col. Oliver North, best known to the public for his role in the Iran-contra scandal.

One curious entry in the money-raising effort is the Antelope Valley Springs of Life Ministries in Lancaster, California, a fundamentalist church where evangelist Jim Bakker preached

a few last sermons before he began serving a prison sentence for defrauding members of his PTL ministry. The Springs of Life group is distributing "a slick professional tape" titled "The Gay Agenda," which features nudity and public lasciviousness (*Minneapolis Star Tribune*, February 23, 1993). In February the church averaged 300-500 orders a day from members of the public who had seen short excerpts from the tape on religious television shows and were eager to see more.

A church spokesman said that over 25,000 copies of the tape had been distributed, many to members

of government. Sam Nunn, chairman of the Senate Armed Services Committee was given a copy, as were other members of Congress.

The videotape appears to be especially popular in the upper ranks of the military. Gen. Carl Mundy, Jr., gave a copy to each of the other members of the Joint Chiefs of Staff. And according to the tape's producer, sportscaster Bill Horn, one two-star army general sent him a letter that praised the video as "a splendid teaching vehicle." Soon after, a number of Pentagon officials began requesting the tape.

—Linda Rothstein

The Clinton military budget

In February, the Clinton Administration presented the overall contours—but not the details—of its military budget plans for the next five years. It requested \$263.5 billion in new budget authority for fiscal 1994. By fiscal 1995, according to the administration blueprint, the budget would be reduced to about \$250 billion annually. Three points stand out, aside from the relatively modest nature of the reductions from the previous administration's five-year Pentagon plan.

First, the Clinton team went out of its way to downplay the magnitude of the cutbacks, perhaps wary of the reaction in Congress and among military hawks. The new plan, they argued, was consistent with Clinton's campaign pledge to re-

duce the military budget by \$60 billion over five years. To reconcile these figures with Office of Management and Budget figures, Pentagon briefers dismissed

the \$18 billion in savings from a government-wide personnel salary freeze and reductions in cost-of-living allowances.

They also subtracted the \$10 billion that may have to be trimmed to make up for Bush administration misestimates of future management savings. Most important, they failed to count a \$39 billion budget cut in fiscal 1998, because the campaign pledge went only as far as fiscal 1997. Regardless of the rationale and counting methods, the administration preferred to emphasize the non-defense portions of its budget-deficit reduction package.

Second, the Clinton reductions created great confusion; an extraordinary range of numbers were bandied about. The administration, as noted, preferred to use its \$60 billion in defense reductions. A more accurate total, including fiscal 1998, would be a \$127 billion reduction over the next five years.

Senate Armed Services Committee Chair Sam Nunn, using a different method of calculation, came up with a \$123 billion de-

cline over the next four years. His total included cutbacks in the Bush budget due to lower projections for inflation plus the \$7 billion in cuts Congress mandated in the fiscal 1993 budget. Arizona Republican Sen. John McCain set the budget-slashing record when he suggested that Clinton had proposed cutting President Bush's original military budget by nearly \$188 billion through fiscal 1998. In the wondrous world of Pentagon high finance, all these figures are correct, depending on the factors, the definitions, and the time-frames.

The pro-military members of Congress were remarkably quiet about the Clinton defense plan. True, the military budget was only a part of the Clinton administration's five-year budget deficit and economic stimulus package. Republicans mounted ferocious assaults on the Clinton plans for tax increases and on plans for the spending package. They targeted the new energy tax and the levy on wealthy Social Security recipients. But attacks on the military bud-



MIKE, THE TALENTED BLADE

get cuts were muted.

The primary House Republican alternative to the Clinton plan, advanced by Ohio Cong. John Kasich, included \$60 billion in military cuts—but it hid additional reductions in some larger personnel categories. Kasich thus accepted the majority of Clinton's military savings, but he attempted to downplay its significance. New York Cong. Gerald Solomon offered the other major House Republican budget plan, and in the absence of the communist threat, he went along with the Kasich Pentagon cuts.

On March 17 (fresh from his ninetieth birthday celebration), South Carolina Republican Sen. Strom Thurmond rose to "discuss" rather than to denounce the new five-year plan. Instead of fiery calls to reverse Clinton's cuts, Thurmond mildly urged "the Congress and the administration to proceed with the restructuring of our national security infrastructure

with all the care and due diligence it demands."

Senator Nunn raised warning flags about the Pentagon plans on March 5. Yet his lengthy address was a "this far and no farther" speech. Nunn was especially worried that the appropriations committees might trim the military even more later in the year to fund domestic programs. In a surprise move on March 24, Senator Nunn joined Republican Sen. Pete Domenici of New Mexico in an attempt to restore \$67 billion to the military budget over the next five years. The attempt failed, 58 votes to 41.

With such a quiet response, it is likely that the Clinton military budget will survive this year. But there is a major uncertainty: a few members of Congress already say military reductions will need to be reversed if Boris Yeltsin falls and Russian reforms are reversed.

—J. I.

Simpson recognized as space pioneer

John A. Simpson—a founder of the *Bulletin*—is the latest recipient of the National Academy of Science's Aretowski Medal for research in solar physics and solar-terrestrial relationships. The prize is awarded once every three years.

Simpson was cited for "pioneering studies of the properties of the charged particle environment of the sun, the Earth and the other planets." Simpson has built scientific instruments for 31 spacecraft, including the Ulysses spacecraft now speeding toward a polar orbit of the sun. His previous honors include the Gagarin Medal for Space Exploration, awarded by the Soviet Academy of Science.

Simpson is the Arthur Holly Compton Distinguished Service Professor



John A. Simpson

Emeritus in physics at the University of Chicago. In 1945, he chaired the Atomic Scientists of Chicago, the group of Manhattan Project scientists who founded the *Bulletin* that year. He remains a member of the magazine's Board of Directors.

Keeping "it" down on the farm

The "tank farm" for storing nuclear waste at the Hanford, Washington, plutonium production complex has been a safety concern for some time. Special attention has been paid to one tank known as the 101-SY, which contains a witches' brew of chemicals. This tank "burps" periodically, and there have been concerns that it might explode. Three years ago the Energy Department agreed to improve the monitoring of 53 storage tanks that are

considered the most dangerous, placing them on a special "watch list."

In February, however, Oregon Cong. Ron Wyden, a Democrat, made public the Energy Department's internal "Red Team" report on the Hanford waste tanks (*Chemical & Engineering News*, March 1, 1993). When the Red Team visited, 36 of 109 tank monitoring gauges had failed, and 33 of them had been out of service for more than three months. The team reported that an-

other 3,000 pieces of equipment, including pumps, compressors, gauges, and ventilation systems were also out of service. Older equipment often took more than nine months to be repaired, reported the Red Team—not, they said, that it mattered much, since most of the information provided by older equipment was of "indeterminate quality."

On a more upbeat note, the Red Team found that the tanks' contents were being sampled more frequently. On the other hand, the volume of samples far outstripped the ability of the Hanford laboratory to conduct analyses. As a result, there was a backlog of unanalyzed materials, which presented a problem

that the team predicted would continue for some years.

Michael Payne, the Westinghouse Hanford Company's manager of the tank farm, responded that the Red Team report reflected conditions as they existed in 1992. Since then, said Payne, "tremendous progress has been made."

—L. R.

David Albright is the president of the Institute for Science and International Security in Washington, D.C. John Isaacs is executive director of Council for a Livable World in Washington, D.C. Both are *Bulletin* contributing editors. Linda Rothstein is the managing editor of the *Bulletin*.

North Korea rejects IAEA's demand to inspect nuclear waste; Depleted uranium as a military—and a propaganda—tool

NON-PROLIFERATION TREATY

North Korea drops out

By DAVID ALBRIGHT



U.S. and South Korean troops in mock battle formation as part of the 1993 "Team Spirit" exercise, March 8, Pohang, South Korea.

On March 12, North Korea announced that it was withdrawing from the Nuclear Non-Proliferation Treaty (NPT). Soon afterward, it formally notified the U.N. Security Council of its intention. But a member must notify the Security Council and all other signatories three months in advance of withdrawing, so the treaty remains binding on North Korea at least until mid-June.

North Korea gave two reasons for withdrawing. First, the United States and South Korea began their joint "Team Spirit" military exercises in early March. North Korea has always said that it viewed these exercises as provocative; the most recent one, it said, was a "nuclear war rehearsal."

Team Spirit exercises were not held last year, after North Korea made several important concessions. Seven years after signing the NPT, North Korea had finally accepted International Atomic Energy Agency (IAEA) inspections of all its nuclear facilities as required by the treaty. And it had signed a bilateral agreement with South Korea in which both countries agreed not to build facilities capable of making nuclear explosive material.

Second, in the days leading up to the March 12 announcement, it became clear that the North was incensed by the IAEA Board of Governors' demand on February 25 to conduct "special inspections" of two sus-

pected nuclear waste sites at Yongbyon, a nuclear complex about 100 kilometers north of Pyongyang. The IAEA wanted to inspect these two undeclared, possibly camouflaged, sites to verify its suspicions that they may contain radioactive waste generated during the process of separating plutonium; such inspections might determine whether or not North Korea had hidden any plutonium from the inspectors.

In early February, during the IAEA's sixth visit, North Korea refused to allow inspectors to visit these waste sites, claiming that they were non-nuclear military sites. The board then set a March 25 deadline for the North to agree to the special inspection. On April 1, the board found the North in noncompliance and referred the matter to the U.N. Security Council for action, including the possible imposition of economic sanctions.

Based on sophisticated analyses of the data gathered during six earlier inspection trips, the IAEA has concluded that the North has not declared its complete stock of separated plutonium—the form most directly usable in nuclear weapons. One IAEA official said the agency does not know if the North has separated "grams or kilograms of plutonium," but it has certainly separated more than it has declared. IAEA officials worry that North Korea is now aware of the sophistication of the IAEA's techniques and has decided to withdraw from the treaty rather than risk exposure by allowing more inspections.

In testimony before the Senate Committee on Governmental Affairs on February 24, CIA Director R. James Woolsey gave a worst-case assessment: "Of greatest concern is the real possibility that North Korea has manufactured enough fissile material for at least one nuclear weapon, and is hiding this from the IAEA." A first nuclear weapon requires roughly 10 kilograms of separated plutonium, with roughly half lost during processing and fabrication.

The North has separated plutoni-

um from irradiated fuel discharged from a small, 5-megawatt, gas-cooled, graphite-moderated reactor at Yongbyon (see November 1992 *Bulletin*). But this reactor, started in 1986, has not operated reliably.

The North has stated that because of its operating problems, the reactor still contains the fuel that was loaded into the core when it first started up. This means that the reactor has operated only a small fraction of the time and achieved only an estimated 10 to 20 percent of its full operating capacity. The core may contain an estimated 5–10 kilograms of weapon-grade plutonium.

Even though other developing countries have experienced equally low-value capacities, this claim is another reason why the IAEA is suspicious. If fuel has been secretly unloaded, the North could possess more plutonium than it has declared.

When the fuel is unloaded, the IAEA can check the operating history of the reactor and estimate the total amount of plutonium it has produced. But this analysis could take six months if the agency is to insure that it will detect any elaborate North Korean "cheating scenarios." According to a U.S. official, because the reactor's fuel-charging machine is being repaired, the fuel will not be unloaded until at least this spring.

Determining the total amount of plutonium North Korea has produced is important, but verifying the amount actually separated from irradiated reactor fuel is the key to knowing whether North Korea has the capability to make nuclear weapons. The North has been building a plutonium separation plant at Yongbyon, which it calls a "Radiochemical Laboratory." It told the IAEA that this facility separated gram quantities of plutonium in March 1990 from a small number of damaged fuel elements taken out of the 5-megawatt reactor. (The fuel's outer metal casing or "cladding" was damaged during reactor operations and had to be removed.) One Western official said that the North declared that it had separated between 50 and 100 grams of plutonium, although he refused to be more specific.

The North also admitted that it separated minute quantities of plutonium in laboratory-scale "hot cells" in

Pyeongbyon in 1975. The hot cells, provided by the Soviet Union, were used to process irradiated material from a Soviet-supplied research reactor. At the time, the reactor was not under IAEA safeguards, although safeguards were applied beginning in 1977. The North has not provided any record of this separation, although inspectors did visit the site in the spring or summer of 1992. North Korea's admission that it separated plutonium so long ago also fuels speculation that it has separated more plutonium than it has declared, either at the Radiochemical Laboratory or at an undiscovered pilot plant.

Because of its suspicions, the IAEA has carefully verified the North's declarations about separated plutonium. During its inspections of the Radiochemical Laboratory, the IAEA collected "samples" of separated plutonium, of material caught up in separation processing steps, and of different types of nuclear waste generated during the various separation operations.

According to an IAEA official, the facility operators were not prepared to take samples from waste that was temporarily stored at the site. When inspectors asked for samples of the highly radioactive "fission product" waste, North Korean technicians had to improvise a way to get into the waste. North Korean officials told the IAEA that this procedure caused some facility operators to receive more than allowed doses of radiation.

The samples have been analyzed by the IAEA's laboratory at Seibersdorf, Austria, and by the IAEA's affiliated laboratories in Europe and the United States. These analyses uncovered discrepancies that led the IAEA to conclude that the North has separated more plutonium than it has declared.

One set of analyses focused on checking the North's declaration that it separated plutonium only during March 1990. This method depends on measuring the amount of americium 241 in "smear" or "swipe" samples from the "hot" insides of glove boxes located at the end of the separation process, where essentially pure plutonium is processed and handled. Since americium 241 is a decay product of plutonium 241, the amount of americium 241 in the samples indicates the period of time that has passed since

the plutonium was originally separated. The IAEA's analyses indicate that there were distinct separation efforts in 1989, 1990, and 1991.

Another analysis tried to verify that the declared plutonium and the waste had originated from the same irradiated fuel rods. The IAEA compared the isotope ratios of the plutonium remaining in several waste samples to the ratios in the separated plutonium. Ideally, both the plutonium and the trace quantities of plutonium in the waste samples should have the same ratio of principal plutonium isotopes—239, 240, and 241. They found significantly less plutonium 240 in the waste than in the separated material. However, a Western official said there is more uncertainty about this conclusion than the one involving americium.

Because of these discrepancies, the IAEA wants to inspect the two nuclear waste sites to search for more plutonium-separation waste. U.S. satellite photos, taken over many years, show what appear to be two camouflaged nuclear waste sites near the 5-megawatt reactor and the Radiochemical Laboratory; they are big enough to handle large quantities of liquid and solid nuclear waste.

One set of photos shows a suspected outdoor waste facility. In early photos the site's layout resembles that of waste sites associated with Soviet-supplied research reactors, with a distinctive pattern of round and square holes for liquid and solid nuclear waste. One Western official said it resembled a site in Iraq next to its Soviet-supplied research reactor. Later photos show the same site, now covered and landscaped, effectively hiding it from inspectors or satellite surveillance.

The second site is a large building that, according to a Western official, appears to be connected to the Radiochemical Laboratory by a trench or canal that could contain pipes. Early photos show a two-story building, but in later photos the building has only one story because dirt has been pushed up around the lower story to turn it into a basement. The IAEA suspects that the basement contains reprocessing waste from the Radiochemical Laboratory.

During an earlier inspection, IAEA inspectors visited the building, but

found no evidence of a basement. They later told the North that they might need to drill through the floor to gain access to the level below.

Although inspections of the waste sites could indicate whether the North has separated more plutonium than it has declared, they cannot reliably determine exactly how much plutonium the North has separated. Verification of the total plutonium North Korea has separated would require continuing access to North Korea's nuclear sites, including the

5-megawatt reactor.

At press time, the United States was leading an international effort to convince the North to reconsider its decision to withdraw from the NPT. Its departure would set back efforts to stop the global spread of nuclear weapons and, in particular, would risk the stability of east Asia. ■

David Albright is the president of the Institute for Science and International Security in Washington, D.C., and a Bulletin contributing editor.

GULF WAR

The desert glows—with propaganda

By WILLIAM M. ARKIN



Saudi troops examining a disabled Iraqi tank in Kuwait, February 24, 1991.

"You remember at the beginning of the war when they claimed they would use tactical nuclear weapons if needed?" the governor asked. "Concerned

and vigilant people in America must ask, where did these bombs go?"

I had asked Lt. Gen. Latif Sabawi, governor of the Iraqi province of

Basra, if he could describe the effects on Iraq of the remnants of depleted uranium shells and bullets fired by U.S. tanks and planes. He had no idea what I was talking about, and he was winging it. He thought I was asking about nuclear weapons. "I have been in Basra for many years, and even the climate has changed since the war." He added, "Something vicious has been thrown over Iraq."

When I arrived in Iraq in the beginning of February to continue my investigations of the effects of the Gulf War, officials in Baghdad were quick to ask whether I had read "Making the Desert Glow," an op-ed article by Eric Hoskins in the January 21 *New York Times*. The article deplored the effects of depleted uranium in the Gulf; it was illustrated with an ominous radioactive symbol, and a "pull-quote" that read: "U.S. uranium shells used in the Gulf War may be killing Iraqi children." When I asked Iraqi officials if they thought the story was true, they said it was in the *New York Times*. In other words, the truth didn't matter.

My hosts directed me to a November 1991 article in the London *Independent* claiming that a secret British government report had concluded that the use of depleted uranium might cause 500,000 deaths. I was also referred to reports by a German physician, Siegwart Gunther, who said that mysterious uranium-caused diseases had appeared in Iraq. On the desk of my Foreign Ministry sponsor was Ramsay Clark's new book, *The Fire This Time*, which concludes that "entire regions in Iraq and Kuwait may be deadly and uninhabitable forever."

What was the truth about the use of depleted uranium in the Gulf War? Outside Iraq these claims had provoked widespread media interest. But once inside Iraq and away from the Baghdad propaganda machine, the story simply evaporated. Reports of disastrous civilian contacts with depleted uranium proved to be purely hypothetical. Even the *Independent* article cautioned that to achieve the predicted number of deaths, "Uranium shells would have to be pulverized into dust and 500,000 people would have to line up in the desert and inhale equal quantities."

But most of those who have broadcast the depleted uranium story have

used it as a tool to attack the Bush administration's Iraqi policy, or to call attention to contamination in the United States caused by the manufacturing and testing of weapons that use depleted uranium. So far they have not been interested in clarification.

The Director General of the Basra Health Department, Dr. Abdul Amir Thaner, told me that the mysterious diseases reported in the *New York Times* had not appeared in southern Iraq, and that there had been no increase in kidney disease (a sign of heavy-metal poisoning) since the war. With most sophisticated medical equipment incapacitated by a lack of spare parts, Dr. Thaner added, and a breakdown in the collection of health statistics in 1990 and 1991, claims of increased cancer incidence made by the news media or by Baghdad were impossible to measure. If there was an increase in cancer, the chief medical officer in southern Iraq didn't know how it would be detected or measured.

Civil defense authorities were also skeptical. They stated that they had neither the instruments nor the manpower to collect the depleted uranium that had been used. They referred me to the physics department at Basra University. Professors there had measured gamma radiation in the city of Basra and surrounding towns after the *Independent* article appeared, but they found no radiation levels over background.

Still, depleted uranium's "nuclear" moniker has led to overblown stories that divert attention from otherwise straightforward problems and solutions. Depleted uranium is a toxic and radioactive substance—abundant and cheap—first adapted for military missions in the late 1970s and used for the first time in combat in the Gulf War, admittedly with little regard for its environmental impact or its health consequences. At the same time, there is no evidence of general environmental or health effects in Iraq, and those who persist in describing theoretical effects as actual events have polarized the debate and undermined an otherwise clear case.

For the 35 or so U.S. soldiers (and their many Iraqi counterparts) actually exposed to depleted-uranium poisoning, and for the workers and residents endangered by manufacturing

and testing in the United States, there is a problem. U.S. forces should eliminate the use of depleted-uranium penetrators and switch to tungsten, another heavy metal, while relying on other, more effective anti-tank weapons.

Depleted uranium is a waste product, the "tails" from the uranium enrichment process. After the fissile isotope uranium 235 is concentrated, only the uranium depleted of 235 is left (hence, "depleted" uranium). This depleted uranium has about the same level of radioactivity as natural uranium, but as a metal it is extremely dense. Like tungsten, it is about three times as dense as steel, and therefore useful in armor-penetrating weapons. Vast amounts of depleted uranium are available from the Energy Department's uranium enrichment empire, and it is provided virtually free of charge to Pentagon contractors. The military uses purified and machined depleted uranium for two purposes: armor-piercing bullets (fired from tanks, aircraft guns, and shipboard guns), and more recently, for armor in the newest model M1 Abrams tank.

When a depleted uranium bullet hits a hard object, the kinetic energy is transformed into such high levels of thermal energy (heat) that it virtually ignites the molten slug, causing splintering and burning. The break-up, heat, smoke, and oxidation create shrapnel and uranium oxide dust particles that may be inhaled, ingested, or implanted. The immediate victims of depleted uranium are soldiers who survive an attack on their vehicle by depleted-uranium weapons, or soldiers who may be contaminated by the armor in their own tank if it is breached. In the Gulf War, U.S. soldiers who survived "friendly fire" attacks, and possibly those who came into contact with contaminated vehicles are now thought to be at some risk.

Documents released under the Freedom of Information Act indicate that the U.S., British, and possibly the Saudi, armies fired about 4,000 depleted uranium-tipped tank rounds, and that U.S. Air Force A-10 aircraft fired some 940,000 30-millimeter uranium-tipped bullets. About half were fired in Kuwait and half in Iraq. A-10s fired the overwhelming share (95

percent) of depleted uranium, as aircraft attacked armored and other vehicles throughout both countries. Depleted-uranium bullets were used extensively in anti-Scud missile operations, where A-10s conducted road attacks, particularly in western Iraq. All told, about 300 metric tons of uranium litter the battlefields.

Most of the depleted uranium is in uninhabited areas where the dangers of contact, ingestion, or inhalation are small. Nevertheless, depleted uranium emits ionizing radiation, both alpha and gamma, and it is a carcinogen. Each slug emits approximately 15 millirems per hour of gamma radiation at the surface. An individual—soldier or child—who might handle or collect a heavy slug would be exposed to low-level radiation, and would have to carry the bullet constantly for a month to have a one percent chance of incurring a cancer from this exposure. (This calculation is based on a cancer rate of one in 1,000 per cumulative rem of exposure.)

The army now admits that some U.S. soldiers were unknowingly exposed in the Gulf War. The army follows standard Nuclear Regulatory Commission guidelines for low-level radioactive exposure, and both concede that the relationship between radiation dosage and health risks at low levels of exposure is unclear. The latency period for a solid tumor due to low-level radiation is 10–20 years, and 4–5 years for leukemia. The Defense Department and the Department of Veterans Affairs have begun an identification and health monitoring program for soldiers who were exposed.

Beyond direct contamination, depleted uranium poses a general environmental and human health problem. The Defense Department readily admitted in a May 1991 memorandum to Cong. Les Aspin, then chairman of the House Armed Services Committee, that the use of depleted uranium "results in remnants that are subject to atmospheric oxidation and/or aqueous corrosion. Either process can lead to environmental contamination that has the potential to cause adverse impacts on human health, primarily through the water pathway."

The Pentagon has already spent a considerable amount of money to recover contaminated U.S. vehicles on

(continued on page 46)

REMEMBERING BERNIE

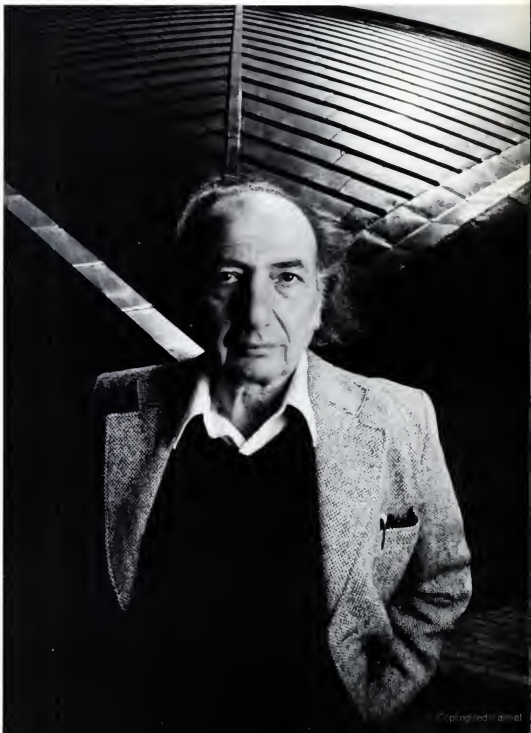
**Bernard Feld, who witnessed the beginning of the nuclear age,
became an ardent, indefatigable champion of peace.**

Those of you who saw the last issue of the *Bulletin* may have noted that Bernard T. Feld—Bernie, to his friends and colleagues—died February 19, after an illness of many years. Bernie was a distinguished physicist at the Massachusetts Institute of Technology. Before that, he was a member of the Manhattan Project. But he was best known, perhaps, for his tireless efforts on behalf of world peace and the abolition of nuclear weapons. He pursued these related goals as an individual and as a pivotal figure in the Pugwash movement, the Council for a Livable World, the Albert Einstein Peace Prize Foundation, and as editor-in-chief of the *Bulletin* (November 1975 to December 1984). He was also a long-time member of the *Bulletin's* Board of Directors.

The Council for a Livable World has established the Bernard Taub Feld Memorial Fund to continue Bernie's work. Checks for the fund may be made out to the Council for a Livable World or to the Council for a Livable World Education Fund. A contribution to the former would not be tax-deductible; a contribution to the latter would be. In either case, the address is 110 Maryland Avenue NE; Suite 409; Washington, D.C. 20002.

On the next four pages, the *Bulletin* presents the comments of three of Bernie's friends, as well as one of his *Bulletin* editorials. Bernie was a man of wit, passion, intellect, and economy of style. He is greatly missed.

Bernard T. Feld



Bernie Feld and I knew each other as undergraduates at City College of New York and as graduate students at Columbia University. It was the Depression, and Bernie had a rough time financially—as an undergraduate, he paid his dollar-a-week rent from his government-supplied student food allowance. But things improved for him when he graduated in 1939 and started teaching night courses at City College.

Early in 1941, when Bernie was at Columbia, Leo Szilard telephoned and asked him to lunch. Szilard convinced Bernie to assist him in calculating the possibility of producing a nuclear chain reaction. Szilard put Bernie to work doing theoretical calculations in Szilard's room at the King's Crown Hotel. He gave

Bernie a lovely 20-inch slide rule, which always remained Bernie's favorite computer. At the same time that Bernie was working for Szilard, he was taking courses, studying for his Ph.D., and working as a research assistant in I. I. Rabi's molecular beam group. He cut back on sleep.

Bernie was excited by the early experiments on chain-reacting piles, and Szilard encouraged him to join in Enrico Fermi's experimental work. When I came to Fermi's project in January 1942, Bernie taught me the experimental and theoretical neutron physics that he had learned from Fermi.

Before joining the project, I, like Bernie, was a night person at Columbia. I was an industrial spectroscopist and student during the daytime, and I did my graduate research at night. Another graduate student who liked to work all night was Julian Schwinger. (Later, in

"Cold warriors take over," a March 1980 editorial

By BERNARD T. FELD

The outstanding dilemma for American foreign policy today lies in the extent to which our government feels compelled to cut off our nose to spite the Soviet face. I refer, of course, to the complete breakdown of arms control negotiations between the East and West—most especially the indefinite shelving of SALT, ostensibly in response to the Soviet invasion of Afghanistan.

Détente, however defined, was a delicate flower. Even before Afghanistan it had severely wilted from assaults on both sides. In the West, there was the U.S. Senate's failure to ratify SALT II, the rude NATO rejection of Premier Brezhnev's bid to negotiate on the deployment of new intermediate range nuclear weapons systems in Europe, and the Carter administration's increasing tendency to play the "China card." In the East, there was the rapidly growing Soviet military expansion and the obvious lack of Soviet sympathy for U.S. frustration in the crisis over the hostages in Iran. Nor could even the most cynical Soviet propagandist have expected détente to survive the military takeover of Afghanistan.

The recent repressive actions against Andrei Sakharov and other dissidents are therefore widely interpreted as indicating that Soviet authorities have written off détente for the indefinite future—that the headline forces are now completely in the ascendancy in the Kremlin.

It is not surprising that the growing power of Soviet militarists is mirrored in the United States. Impossible as it is to determine which side was originally to blame, what has always been clear is that in our relations with the Soviet Union, intransigence feeds on intransigence, toughness begets toughness, and force invites force.

The cold warriors on both sides have always been each others' best allies.

What makes the current situation much more frightening than all previous East-West confrontations, however, is that it comes at a time when the defenses of public opinion against the use of nuclear weapons seem to be crumbling under the onslaught of a fierce propaganda campaign from the military establishments. The insane idea that nuclear weapons are militarily usable, that nuclear wars can be fought and even "won," is being bandied about by paranoid weaponers and stupid politicians. They hope to benefit from the national frustration that comes from learning that being number one in the nuclear business counts for little toward the ability to control a world in turmoil.

What is worse, the simultaneous breakdowns of détente and SALT have given an even more dangerous impetus to the technological military zealots on both sides. They are seizing the opportunity to introduce into our arsenals the kind of nuclear systems (such as the MX missile or the Soviet SS-20) that, while seeming to provide some immediate strategic advantage, in fact guarantee that the Soviet-American nuclear standoff will become increasingly unstable or crisis-prone.

Somehow, in the midst of the current turmoil and disintegrating international communications we must find a way of convincing our leaders to keep the lid on the nuclear arms race, in spite of growing pressures from the cold warriors. SALT II may be on the shelf, or even dead, but Carter and Brezhnev must both act—independently or in concert—as though it were in force. And they must also contrive to postpone the deployment of systems that will permanently exclude a future for SALT.

Otherwise, we are on the slippery slope that can lead only to nuclear holocaust. ■

the 1950s, Bernie and Julian met regularly to discuss experimental results, especially in elementary particle physics.)

We all became good friends at Columbia. Another of Bernie's friends was the violinist Isaac Stern, whom he met through Hyman Goldsmith, a neutron physicist and instructor at City College. Hy had an apartment that consisted of a single, giant room in a tower on Central Park West. It was so remote from other apartments that musicians—Stern and others—could practice there late at night. Bernie loved to attend these free chamber music sessions.

In April 1942 the neutron pile work at Columbia was moved to the University of Chicago, where it played a key role in what was later called the Manhattan Project. Along with Fermi, Bernie and I moved into International House on the Chicago campus. We spent whatever free time we had together in the evenings and on weekends for several months. Bernie and I had large rooms in the tower, Bernie's above mine. He would work or read nearly all night long and could not be awakened by alarm clocks. In the morning, it was my job to tip him out of bed onto the floor. Unfortunately, that operation eventually led to one of his toes being crushed. Afterward, shaking the bed was adequate. During this period, Bernie also spent time trying to teach me Yiddish. His father, a dress cutter, had encouraged him to become a scholar of Yiddish literature; he also corresponded with his grandparents in Yiddish.

During 1942 and 1943, Bernie's work for Szilard was both theoretical and experimental. He directed a small experimental group that, among other things, was working on nuclear reactor designs for the future—he and Szilard were years ahead of other people. At the same time he was also completing a theoretical molecular beam calculation that was the basis of his Ph.D. thesis at Columbia. In 1944, he went to Los Alamos, where he engaged in the dangerous work of establishing criticality in weapons—"tickling the dragon's tail." We did not see each other while he was at Los Alamos.

In 1945, after he left Los Alamos, we both worked on setting up atomic scientists' organizations, and he devoted a great deal of attention to pressing Congress for the passage of the McMahon bill, which led to the civilian control of atomic energy. He courted Eliza McCormick in Chicago, and he joined the staff of the Massachusetts Institute of Technology in 1946.

In 1951, Bernie arranged for me to join the staff of the Laboratory for Nuclear Science at MIT, and we collaborated on experiments for eight years. With others, we co-authored seven papers on high-energy nuclear physics and elementary particle physics. These exper-

iments involved high-energy X-rays from the MIT electron synchrotron and also meson beams from the proton accelerators at both Brookhaven and Berkeley Laboratories. One of our most significant experiments, done with Dave Ritson, helped to establish that what was believed to be a fundamental law of reflection symmetry (parity) was violated in the decay of strange mesons.

Bernie taught a wonderfully clear course in particle physics, and his lectures were the basis for a book that has been exceedingly helpful to others teaching the subject. Even as a highly active and productive particle physicist, Bernie kept working on international efforts for peace. He and Liza raised two neat daughters, whom Bernie called Leafie and Ellen.

He must have done all these things on even less sleep than he had as a graduate student. If you were to add up all of Bernie's waking hours, he probably clocked 150 years of a normal person's life. ■

Albert Wattenberg is a distinguished physicist emeritus at the University of Illinois in Champaign-Urbana.

By JOSEPH ROTBLAT

Bernie Feld and I both worked on the Manhattan Project in Los Alamos in 1944, but it was only later, when Bernie was at the Massachusetts Institute of Technology and I was back in England that we discovered our common passion and belief. We passionately abhorred war and violence, and we believed that scientists have both the duty and the competence to help the world avert the dangerous misuse of science and technology. I also shared Bernie's "congenital optimism" about the eventual outcome of such efforts. After Pugwash began, our relationship turned quickly into a warm, lifelong friendship that sustained me throughout the years—particularly when my own optimism occasionally faltered.

Bernie shared my conviction that any meaningful effort to prevent a nuclear holocaust would have to involve direct discussions with scientists from the other side of the ideological divide. This opportunity arose shortly after the Russell-Einstein Manifesto in 1955, which called on scientists to gather in conference. U.S.-Canadian industrialist Cyrus Eaton offered to finance such a conference if it were held in his birthplace—Pugwash, Nova Scotia.

Thus started the Pugwash Conferences on Science and World Affairs, a movement of scientists in which Bernie played a pivotal role, making fundamental contributions both to the



A pick-up football game at Los Alamos, in 1944 or 1945. Bernie is at the extreme left.

substantive debate and to the organization. He became a member of the Pugwash Council (then called the Continuing Committee) in 1963, the year he was also elected chairman of the U.S. national group, under the auspices of the American Academy of Arts and Sciences. At that time there was a move among U.S. Pugwashites to distance themselves from Eaton, who was considered by some to be too radical. As part of this move, some of the Pugwash scientists suggested that the movement's name be changed to Conferences on Science and World Affairs, known as COSWA, or at most, P-COSWA, with the P silent. But Bernie—always a radical—made sure that the Pugwash name was fully pronounced in the title.

After serving as secretary-general of Pugwash for 16 years, I felt that the time had come to hand the job over to a younger person. But finding a replacement turned out to be very difficult, particularly since our Soviet colleagues always insisted that the secretary-general not be a citizen of either of the two superpowers. Nevertheless, they had such a high regard for Bernie, as did the rest of us, that he was elected unanimously. The only stipulation was that Pugwash's headquarters

remain in London. In 1973, Bernie came to London on a sabbatical from MIT.

Formally, Bernie became a visiting professor at the Imperial College, but in practice he was engaged full time on Pugwash matters. During the first 18 months (until his fatal illness, which he fought for 17 years), he traveled extensively, visiting 21 countries, stimulating existing Pugwash groups while helping to establish new ones. He later said that his term as secretary-general of Pugwash was the most rewarding time of his life. He was the chairman of the executive committee for ten years and remained a member of the Pugwash Council until the end of his life, having been again reelected in September 1992.

Throughout his years in Pugwash, Bernie strove indefatigably for a saner world. While stressing the vital importance of science and technology, he insisted that these disciplines should be used as tools to establish a permanent peace. And he fought vigorously the pernicious notion of the armaments lobby that "whatever is technically possible must be developed, and whatever is developed must be deployed." A strong opponent of the Roman dictum—if you

want peace, prepare for war—his motto was “If you want peace, you must work and prepare for peace.”

Abominating war and military solutions, he always emphasized the “importance of accommodation in contrast to confrontation.” And he applied this approach in his day-to-day dealings with people. A man of integrity, he practiced what he preached. His amiable disposition endeared him to all he met. Always good-humored, with a host of good stories, he was also kind-hearted and ready to go to any lengths to help people in need. Love of humankind, individually and as a whole, permeated his entire life. And he was loved by everybody in return. ■

Joseph Rotblat is president of the Pugwash Conferences on Science and World Affairs in London.

By KOSTA TSIPIS

Not long after I came to the Massachusetts Institute of Technology (MIT) in the fall of 1966, I became aware of the extraordinary activities of the professor two doors down the hall from my office. He would rush down to Washington to testify, travel all over the world lecturing on the dangers of nuclear war, and organize conferences that were essential “countervoices” to the Pentagon’s dangerous and incessant demands for more weapons. My abhorrence to war and violence, a remnant of a childhood spent in the terror of Nazi-occupied Greece, resonated with his passionate opposition to war. Finally I went to see him. “Professor Feld,” I said, “you do these very important things on behalf of human survival and sanity. How can I help? How can I be a part of these efforts?” He lifted his eyes from the papers on his oversized desk and said, “You work.” Thus started a collaboration and a friendship that lasted until February 19, when Bernie died peacefully at the end of a long illness that had tormented him on and off since 1975.

In 1968 we worked to show the folly of MIRVing land based ballistic missiles. Then we calculated the number of nuclear detonations that would create the globally lethal conditions depicted in the film “On the Beach.” (One “beach,” we decided, was about a million megatons exploded on the ground.) Then came the conferences on “New Technologies and the Arms Race” and “The Future of the Sea-Based Deterrent,” both of which produced useful volumes. About that time Bernie received what he said was one of his life’s deepest satisfactions: He found that his name was

high on President Richard Nixon’s infamous “enemies” list—“I must be doing something right,” he told me with relish.

By 1977 we decided that we needed a center at MIT where physics faculty and students could get together and work on technical and scientific ideas for the control of nuclear weapons and the avoidance of nuclear war. So we started the Program in Science and Technology for International Security, with the encouragement of the department’s chairman and the support of the institute’s president. Not everyone inside or outside of MIT welcomed the program, but again Bernie was not interested in popularity contests.

Bernie’s was an unstinting, unwavering opposition to nuclear arms and an equally strong commitment to the conviction that conflict ought never to be resolved by combat but instead by cooperation and negotiation. He was known as the conscience of the arms control community because he kept reminding everyone of their responsibilities as scientists beyond their laboratories, blackboards, and classrooms. He considered the Program in Science and Technology the vehicle by which we could teach physics students how important—and possible—it is for scientists to contribute to national policy-making in the field of their expertise, and how it is their responsibility to inform the public and the country’s decision-makers on complex technical and scientific issues.

In the department, in Pugwash, and at *The Bulletin of the Atomic Scientists*, Bernie emphasized the importance of involving young scientists in public policy. He was acutely conscious of the need to expand the arms control community beyond the “Los Alamos generation” that he belonged to, and to encourage younger scientists to join the struggle against militarism and the nuclear arms race. All he demanded was that “they work.”

Bernie was unlike anyone else in the U.S. arms control community. Others would come in and out of the arms control arena—some to oppose the Anti-Ballistic Missile Treaty, others to expose the folly of Star Wars. Their contributions were often major, but their efforts were episodic. Bernie was a constant presence around whom arms control efforts would crystallize again and again. Without him, the community’s work would have been less focused and determined. Even though he kept insisting that he had a “worm’s eye view of the world,” his contributions were those of an indefatigable, ardent champion of peace. ■

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SOVIET SCIENTISTS SPEAK OUT

By DAVID HOLLOWAY

Russian bomb designers answer the KGB's claim that espionage, not science, produced the Soviet bomb.

Igor Kurchatov directed the Soviet nuclear weapons program from its inception until his death in 1960. On January 13, the ninetieth anniversary of his birth, Yuli Khariton and Yuri Smirnov delivered a lecture at the Kurchatov Institute, which was established in 1943 when Kurchatov became the director of the Soviet nuclear weapons project. Then known as Laboratory No. 2, it is now the Russian Science Center—Kurchatov Institute.

Khariton was one of Kurchatov's closest collaborators. The two men met in 1925 when Kurchatov joined the Leningrad Physicotechnical Institute, where Khariton was then working. Khariton spent two years at the Cavendish Laboratory in Cambridge (1926–1928) and obtained his doctorate at Cambridge under the supervision of James Chadwick. From 1939 to 1941, Khariton did pioneering work with Yakov Zeldovich on nuclear chain reactions.

When Kurchatov was appointed scientific director of the nuclear project—or the “uranium problem” as it was known in the Soviet Union—he asked Khariton to take charge of atomic bomb development. Khariton headed the bomb group at Laboratory No. 2 during the war, and he became the scientific director of the first Soviet nuclear weapons center at Sarov, 400 kilometers east of Moscow, in 1946. His position might be considered as the Soviet equivalent of J. Robert Oppenheimer.

Khariton remained scientific director of the nuclear weapons center, which was first

called KB-11 (Design Bureau 11), and is now known as the Russian Experimental Physics Research Institute, until 1992. This is the center that Sakharov refers to in his memoirs as “the Installation”; it is commonly known as Arzamas-16.

Khariton's co-author, Yuri Smirnov, is a theoretical physicist who is now a senior researcher at the Kurchatov Institute. Smirnov spent several years in Andrei Sakharov's group at Arzamas-16 in the 1960s; he took part in the design of the 50-megaton bomb detonated on October 30, 1961.

In the audience January 13 were many veterans of the Soviet atomic project, including some mentioned in the text—A.P. Aleksandrov and L. V. Altshtuler, for example. Apart from general introductory remarks about Kurchatov, the full text of the lecture begins on page 20. The headings that break up the text were, however, added by the *Bulletin*.

Although the lecture's chief attraction for the casual reader may be its insider anecdotes about the scientists' experiences with Joseph Stalin and Lavrenti Beria, its main purpose was to rebut some of the “myths and legends” about the Soviet nuclear weapons program that have appeared in the Russian press and in Western publications. The authors are especially eager to address two particular issues: the role that intelligence played in the Soviet nuclear program, and the nature of the first Soviet hydrogen bomb tests.

In the last year and a half, the Russian press has published a number of articles about the importance of espionage to the Soviet atomic project. These articles have quoted documents declassified by the KGB, among them two memoranda that Kurchatov wrote in March 1943, excerpts of which are also cited in this lecture. The declassified documents reveal that the Soviet Union obtained a number of Manhattan Project secrets, as well as the design of the first American plutonium bomb, which was tested at Alamogordo on July 16, 1945.

Khariton and Smirnov point to the work done by Soviet nuclear physicists before 1941, and they wholly reject the argument that Soviet scientists can claim little credit for the first Soviet atom bomb. Moreover, they argue that the decision to copy the American bomb was the correct one—the Soviet Union had received a detailed description of the American bomb from Klaus Fuchs, and it was determined to acquire the bomb as quickly as possible. Khariton and Smirnov also want to explain the decision to copy the American bomb to other atomic project veterans, who were

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not aware of the role espionage played in the Soviet program until the last two years.

A second major issue in the lecture is the hydrogen bomb. Khariton and Smirnov reply to two assertions that have been made in Western literature: that the weapon the Soviet Union tested on August 12, 1953, was not a true thermonuclear weapon, but a boosted fission weapon of the kind tested by the United States in 1951; and that analysis of radioactive debris from the U.S. "Mike" test on October 31, 1952, gave Soviet physicists crucial information that enabled them to test a two-stage thermonuclear weapon in November 1955.

Khariton and Smirnov argue that the bomb the Soviet Union tested on August 12, 1953, was a true thermonuclear bomb, not a boosted fission weapon. They say that the basic design of that weapon could have been used to produce a thermonuclear bomb with a yield on the order of one megaton. This fits in with the account given by Sakharov, who makes it clear in his memoirs that he believed that a second-generation version of the same design could have produced a yield significantly greater than the 400-kiloton yield of the August 1953 test. But when Soviet physicists independently hit upon the "third idea" (the "Teller-Ulam" idea) in spring 1954, they abandoned work on their first thermonuclear design.

Khariton and Smirnov also reject the asser-

tion that Soviet physicists acquired crucial information from the Mike test. I know from my own conversations in Moscow that a January/February 1990 *Bulletin* article, "The H-Bomb: Who Really Gave Away the Secret," by Daniel Hirsch and William G. Mathews, caused some consternation among those who had worked in the Soviet nuclear weapons program. Hirsch and Mathews argued that the Soviet Union could have obtained important clues about the Teller-Ulam idea from analysis of the radionuclides produced by the Mike explosion. A search of the archives was made in Moscow to discover whether this was indeed so. Khariton and Smirnov concluded that in 1952, Soviet radiochemistry was not far enough advanced, and was too poorly organized, to do intensive analysis of the products of the Mike test. Khariton and Smirnov say that there were limits on what Soviet scientists could have learned from that analysis, and that, in contrast to the first Soviet atomic bomb, Soviet thermonuclear weapons were developed independently.

This lecture represents an effort to provide an authoritative although fragmentary account of the Soviet nuclear weapons program. It is part of the current debate in Russia about that project's history, and about its historical and contemporary significance. That debate is relevant to more than Russia alone, since the Soviet nuclear program was a crucial element in the history of the Cold War, and a matter of worldwide concern today. ■

Authors Yuri Smirnov and Yuli Khariton. Khariton's granddaughter is at right.

THE KHARITON VERSION

By YULI KHARITON and YURI SMIRNOV

Only a handful
of men knew
the full story
of the Soviet
bomb's
creation.

Unlike the United States, the Soviet Union did not keep an historical record of the Soviet atomic project—even of the major events. A regime of strict secrecy meant that only a few of the top leaders of the project had a full picture of events as they were unfolding. Others had to be satisfied with separate fragments of the whole mosaic. Trying to create an accurate account from these fragments is a very difficult task.

Recently, some members of the secret service have exaggerated the role the intelligence community played in the development of Soviet nuclear weapons. We say this with all due respect for the successes, efficiency, and professionalism Soviet intelligence demonstrated in acquiring materials from abroad.

Many participants in the heroic days [of the Soviet bomb program] are no longer with us. And after decades of forced silence, the memoirs of survivors that have begun to appear are inevitably colored by subjective tones. They sometimes contain unintentional inaccuracies and aberrations. Reconstructing the events of the time requires particular care, responsibility, and precision. Furthermore, now that important documents are becoming accessible to the public and artificial secrecy is being abandoned—and contacts and cooperation are being established with foreign colleagues in those fields of atomic technology which were off-limits before—it is important to correct some widespread misperceptions and mistakes with regard to the history of the creation of Soviet nuclear weapons.

In the West, the declassification of documents has yielded its own surprises. For ex-

ample, there is a standard account¹ of why Otto Hahn and Fritz Strassman's article on the fission of uranium was published so rapidly in *Die Naturwissenschaften*.² According to this story, it was the result of efforts by a disinterested and friendly director of the Springer publishing house, Paul Rosbaud. In fact, Rosbaud was a British undercover agent who worked under the code-name of "Griffin."³ An intransigent enemy of Nazism, Rosbaud was the first to send word of Hitler's plan to launch a blitzkrieg against England with the help of submarines, about the creation of German missiles to destroy London, and about German attempts to build an atomic bomb. The remarkably rapid publication of the article by Hahn and Strassman was a conscious act on the part of Rosbaud, who managed to see the immense and dangerous consequences of their discovery. He hoped to inform the scientific community without delay about these exceptionally important results, fearing, perhaps, that the results might be suppressed by the Nazi secret services.

"Pigeon language"

The exceptional secrecy surrounding nuclear weapons programs, both in our country and abroad is well known. For a long time we used "pigeon language," even in our scientific reports. This code included words such as "zero point," "gudron," and "sediment." "Zero point" meant a neutron, and "sediment" was a word used for plasma, which was highly regarded at the Kurchatov Institute.

Everyone now knows that "Laboratory No. 2 of the Academy of Sciences" and "LIPAN" were aliases for the Kurchatov Institute. But it would be hard to guess that Privolzhskaya Kontora ("The Volga Office"), "KB-11," "Installation No. 558," "Kremlev," "Moscow, Center 300," and "Arzamas-75" were all synonyms for a single place, currently known as Sarov, or Arzamas-16.

Few people knew the meaning of the abbreviations for the first Soviet nuclear and hydrogen tests. The abbreviations, invented by Gen. V. A. Makhnev, one of Lavrenti Beria's assistants, were: RDS-1, RDS-2, and so on, for *Reaktivnyi dvigatel Stalina*, or "Stalin's rocket engine." Makhnev was later very proud of his invention. Many people know that the West called our first explosions "Joe 1" and "Joe 2," after Stalin. The West was close to a correct decoding.

What kind of history could have been written when an incident like this could take place? In November 1959, Vasili Yemeljanov was one of a small group of Soviet experts who visited the United States. He brought back a recently published book by a Manhat-

tan Project scientist, Arnold Kramish. The book contained a description of the origins of the Soviet atomic energy program based on information available to Americans at that time. The group wanted to translate it into Russian and publish it in our country. But that idea was soon abandoned: it was decided that if it was published in the Soviet Union, the book would indirectly confirm items that were still considered state secrets.

The absence of solid information created fertile ground for fantasy. In the early days of the Soviet atomic program, the United States was the sole possessor of the atomic bomb. But a rumor spread among the population, as if to create a balance, that the Soviet Union had a new weapon of its own, with tremendous destructive force. This one, though, was a low-temperature weapon, a bomb that would instantly freeze everything around it. Even some scientists told versions of this story.

Oleg Lavrentiev is well known to members of the Kurchatov Institute. His letter in 1950 to the leaders of the country initiated research on controlled thermonuclear fusion in the Soviet Union. V. S. Shafranov said of him:

In the army there served this clever guy.

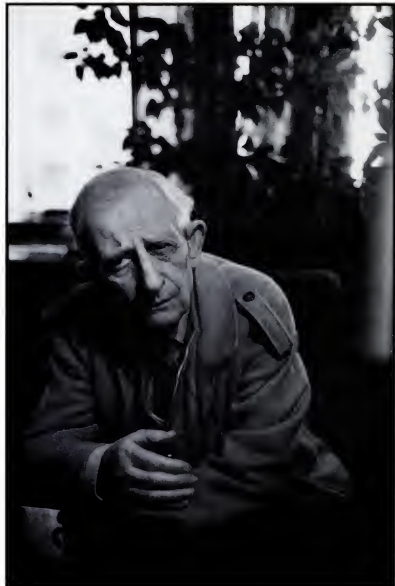
His idea: controlled fusion of nuclei.

Lavrentiev recalls that as late as 1950, during a chemistry lecture, the vice-rector of Moscow University, G. D. Vovchenko explained that "a hydrogen bomb is when you pour liquid hydrogen on the ground and freeze it completely."

Compartmentalizing

In the first years at Arzamas-16 not everyone realized that they were actually engaged in nuclear weapons work. Yevgeni Negin recalled that one of the chiefs of the design bureau was talking to his colleagues on the eve of the first test of the Soviet hydrogen bomb, leaning against the very device. "It is incredible how far secrecy goes in our country!" he said. "Somewhere there is another center where they also work on weapons, and we don't even know about it! Yesterday Malenkov delivered a speech and said that hydrogen weapons have been created in our country. And we don't even know who did it and where!" This was in August 1953.

Access was even more strictly limited when the first atomic device was being developed. The result is that veterans of that project, who are now trying to provide a comprehensive picture of what happened, are the unintentional prisoners of their own imagination or of misconceptions from the past. Thus, one of the participants in that work, explaining the design of the first Soviet atomic bomb, which was tested on August 29, 1949, concluded that almost everything was based on the dimen-



ROBERT DALL THURGOOD

sions of the bomb-hatch of the American plane.

"A photograph of the suspension for the atomic bomb published in an American magazine allowed us to estimate the bomb's size. We knew the dimensions of the bomb hatch. Our Tu-4 was a copy of the B-29. On the basis of the dimensions of the bomb-hatch, the external diameter of the bomb should not exceed 1,500 millimeters and the length, 3,325 millimeters. By subtracting the thickness of the ballistic case of the aviation bomb, and the thickness of the case for the spherical charge—which insures that the design will be strong enough—we will obtain the initial dimensions of the spherical charge of the high explosives. This will define the dimensions of all the design elements in that spherical charge."

The reality was very different. When work on the first bomb was under way, Khariton went to the Tupolev design bureau. But he went there to meet with aircraft designers to

Yuli Khariton.

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Yakov Zeldovich delivering a 1967 lecture in Prague.

make sure that the new bomb would fit into the bomb-hatch of the Tu-4, and to discuss other aspects of transporting the bomb by air.

Stolen plans

As is now well known, the design of the first Soviet atomic bomb was based on a rather detailed diagram and description of the first American bomb, which the Soviet Union obtained through the efforts of Klaus Fuchs and Soviet intelligence.⁶ Soviet scientists received these materials in the second half of 1945. After the experts from Arzamas-16 confirmed that the information was reliable (which required a great number of meticulous experiments and calculations), a decision was made to use the American design, which was tested and known to work, for the first explosion. Given the tension between the Soviet Union and the United States at the time, and the scientists' need to achieve a successful first test, any other decision would have been unacceptable and simply frivolous. The decision to use the American design, and information about how it was obtained, were strictly secret.

After Klaus Fuchs's trial in early 1950, it was common knowledge in the West that he had worked for the Soviet Union, but for us Fuchs's involvement remained a secret. Moreover, this secret was "sanctified" at the highest level. On March 8, 1950, Tass released a special statement: "The Reuters agency has reported the recent trial in London of the English atomic scientist Fuchs who was sentenced to 14 years in prison for divulging state

secrets. British Attorney-General Sir Hartley Shawcross stated during the trial that Fuchs passed atomic secrets to 'agents of the Soviet government.' Tass is authorized to state that this statement is a crude fabrication because Fuchs is unknown to the Soviet government and no 'agent' of the Soviet government had any contact with him."⁷

The shock felt by surviving atomic scientists—when they learned that the first device was a copy of an American bomb—is understandable. They had believed the device, or more precisely its design, to have been an achievement of Soviet scientists and designers until very recently. But revealing the truth about the first test by no means lessens the significance of these pioneers' achievements.

At that dramatic point, when the threat of atomic attack hung over the Soviet Union and millions of human lives were at stake, it was the only logical decision. In addition, in order to build a real device from the American design, it was first necessary to perform a truly heroic feat that required nationwide mobilization: to create an atomic industry, corresponding technologies, a supply of unique, high-quality apparatus, and to train qualified people. All this was done in a country devastated by the war. (After all, did the Americans have any doubts or reservations about their actions when—fearing that they might be overtaken by Nazi Germany—they enlisted the greatest physicists in the world in what became, in effect, an international project to create the atomic bomb?)

A better bomb

After deciding to use the American design for the first explosion, Soviet scientists temporarily slowed down the development of their own, original—and more effective—design. Nevertheless, their experimental work resumed in spring 1948, and in 1949 a "report/proposal" by Lev Altschuler, Evgeni Zababakhin, Yakov Zeldovich and K. K. Krupnikov provided the experimental basis and calculations for a new design that, without a doubt, was more progressive than the American design. This device was successfully tested in 1951. Its explosion was the second test of an atomic weapon in the Soviet Union.

Today, in the Nuclear Weapons Museum at Arzamas-16, models of both devices—the one

based on the American design and the design tested in 1951—are exhibited side by side. The bomb based on the Soviet design weighs half as much as the copy of the American one, but it was twice as powerful. And the diameter of the new bomb was significantly smaller, owing to the original engineering solution proposed by V. M. Nekrutkin for implosion.

A number of Soviet and foreign publications have alleged that the German specialists who worked in the Soviet Union after the war, particularly those in Sukhumi, helped to design the Soviet atomic bomb. Although individual German scientists did participate in developing methods for separating isotopes and producing metallic uranium, this was subsidiary work. German specialists were not directly involved in the design and development of the weapon. American experts, in evaluating Russia's capacity to develop an atomic bomb, dismissed the significance of German scientists. They concluded in 1948: "The Germans themselves made little progress in secret scientific research on atomic energy in the war years. This fact is clearly established in the official reports of highly competent scientific observers. Russia cannot expect any significant help in this direction."⁶

One of the most important German specialists who worked in the Soviet Union, Max Steenbeck, summarized the contribution of his compatriots to the Soviet atomic program in the following way: "Western propaganda . . . on every convenient occasion contended that the Soviet atomic bomb was supposedly created by German scientists. Absolute nonsense! Of course, we played a certain role in the development of the nuclear theme, but our task never went beyond those frontiers where the harnessing of energy clearly turns from its peaceful application to its use for military purposes."⁷

Myth making

Recently, a number of stories have appeared in the press purporting to describe how atomic weapons were created in the Soviet Union or explaining why they were not created earlier. Both journalists and mere storytellers have claimed that some far-reaching discoveries on the path to atomic weapons were made before the war, but their significance was underestimated.

In another preposterous story, it is said that the Americans dropped not two, but three, atomic bombs on Japan. One did not explode, but was preserved. This third bomb was supposedly handed over to the Soviet Union by the Japanese.

The press has also popularized the so-called "Kharkov project."⁸ This story is based on an

October 1940 patent application by two research fellows at the Kharkov Physicotechnical Institute, V. A. Maslov and Vladimir Shipin. The application was titled: "On the use of uranium as an explosive and as a poisonous substance." The essence of this invention consisted of the following: it was proposed to separate a number of subcritical parts of uranium 235 in a bomb "by several neutron-proof partitions made of explosives—silver acetyl, for example—and to destroy these partitions by an explosion." This "invention" has nothing to do with a genuine atomic bomb or its ability to work.

A head start

Looking back we can see that two elements were critically important to the successful development of Soviet atomic weapons. The first was that the Soviet atomic project received the highest priority as a matter of national security. But the second was a group of Soviet physicists who had made outstanding advances before the war. These brilliant young scientists—Yakov Zeldovich, Georgi Flerov, Konstantin Petrzhak and others—and the equally young Igor Kurchatov, who had already become their informal leader—had managed to reach the most advanced levels of world science and to do research of outstanding, pioneering significance.

In 1940, Zeldovich and Khariton elucidated the conditions for realizing a branching fission chain reaction in uranium in a reactor, and proposed the use of heavy water and carbon as moderators.⁹ That same year, Flerov and Lev Rusinov had experimentally determined the number of secondary neutrons during fission,¹² and Flerov and Petrzhak reported the phenomenon of spontaneous fission.¹³ In 1937, Khariton had proposed separating isotopes in a centrifuge and provided a quantitative basis for the process.

In 1943, Kurchatov wrote a famous memorandum that became a kind of manual of nuclear physics for the senior administrators of the atomic project.¹⁴ He pointed out that in June 1941, when research on uranium was suspended in the Soviet Union, Soviet physicists were already investigating specific ways to achieve chain reactions using ordinary uranium: with uranium 235; in a mixture of uranium enriched by uranium 235 and water; in a mixture of ordinary uranium and heavy water; and, finally, in a mixture of ordinary uranium and carbon.

It is less commonly known that before the war Zeldovich and Khariton had elucidated the conditions for a nuclear explosion, and estimated its destructive force. They delivered a report on the topic at a seminar at the Leningrad Physicotechnical Institute in the

Many Russian scientists were shocked when they recently learned that the first Soviet A-bomb was built from a stolen American design.



ROBERT DEL TRENO

Kurchatov memorial,
Kurchatov Institute,
Moscow.

summer of 1939. In 1941, on the basis of still approximate values for the nuclear constants, the same authors, together with Isaak Gurevich, determined the critical mass of uranium 235 and assigned a very plausible, although imprecise, value for it.¹⁵

Nevertheless, apart from a small group of enthusiasts, most Soviet scientists believed that a technical solution to the uranium problem would not be found for 15 or 20 years. When Nikolai N. Semenov sent a letter to his People's Commissariat asserting the need to develop a complex program of research to develop nuclear weapons, he received no answer.¹⁶

Meanwhile, the West was propelled by the fear that Nazi Germany would be the first to solve the uranium problem. Western scientists believed that this task could be solved in a short period of time.

By the end of 1941, intelligence sources reported the beginning of massive research on the uranium problem in Britain and in the

United States. At once, Flerov began to bombard Kurchatov and Sergei Kaftanov, who was charged by the State Defense Committee with responsibility for science, with a series of letters. In these letters Flerov asserted the necessity of returning immediately to the uranium problem and work on the atomic bomb. In spring 1942 he wrote directly to Stalin, emphasizing that the creation of an atomic bomb would be a "genuine revolution . . . in military technology."

In December 1941, Flerov sent Kurchatov, who was then in Kazan, a manuscript. In it he proposed using the "gun" method—that is, the rapid convergence of two hemispheres of uranium 235—to achieve a nuclear explosion. He also proposed "compression of the active material." Kurchatov never parted with his student's manuscript. After his death it was found in his house, in the drawer of the writing desk in his study.

By spring 1942, Kaftanov was convinced, and he and Abram Ioffe sent a letter to the State Defense Committee urging the creation of a research center for the development of nuclear weapons. Later, Kaftanov indicated that he had discussed the issue with Stalin. At the same time, Beria sent a memorandum to Stalin telling him about the beginning of research on atomic weapons in the West.

On February 11, 1943, the State Defense Committee established a scientific and technical research program on the use of atomic energy. Kurchatov was named its leader.

Two documents from early 1943 have now been declassified and are publicly available. These are Kurchatov's handwritten letters to the Deputy Chairman of the Council of People's Commissars of the Soviet Union, Mikhail Pervukhin.¹⁷ The first letter, dated March 7, 1943, is 14 pages long; the second, dated March 22, 1943, is eight pages.

In these letters Kurchatov compared the results of Soviet physicists and the information acquired by Soviet intelligence. He then outlined those areas of atomic research that he regarded as most promising.

"It was very important for us to know that Frisch confirmed the discovery of the spontaneous fission of uranium made by the Soviet physicists G. N. Flerov and K. A. Petrzhak. This phenomenon can create initial neutrons in a mass of uranium, leading to the development of an avalanche process. Because of this phenomenon, it is impossible, until the moment of explosion, to keep the entire explosive charge in one place. The uranium must be divided into two parts which, at the moment of explosion, must be brought together with great speed. This method of setting off an atomic bomb . . . is not new . . . to Soviet physicists. An analogous approach was proposed by physicist G. N.

**Kurchatov
sometimes
thought the
stolen
materials
might contain
disinformation.**

Flerov; he had already calculated the speed with which the two halves of the bomb must be brought together. Articles published in 1939 and 1940 by [Frédéric] Joliot, [Hans von] Halban, and [Lew] Kowarski in France, and by [Herbert] Anderson, [Enrico] Fermi, [Howard] Zinn, and [Leo] Szilard in America, as well as research done in my own laboratory give the same value for the number of secondary neutrons for each fission, and approximately the same general picture of their distribution by energy."

From the very first, Kurchatov treated materials obtained by the intelligence services very cautiously and critically. He wondered whether "the materials obtained do indeed reflect the actual course of scientific research" and he even feared that they might be "fabrications aimed at disorienting our science." Kurchatov was direct: "Some conclusions, even in very important parts of the research, look doubtful to me, some of them are not well grounded." He did not hide his surprise that Western scientists preferred the diffusion method of isotope separation to the centrifuge method.

It was, then, the results of earlier research by the Soviet scientists themselves that put them in a strong starting position when they embarked on a solution to the atomic problem. One should not overestimate the importance of Soviet intelligence community in setting up the atomic program although its efforts and its contribution were commendable.

Uranium "boiler"

Kurchatov was an exceptional leader who organized a strategically correct program from the very beginning. His unerring ability to find correct ways of attaining goals and taking immediate measures despite the scarce and incomplete initial scientific data was clearly shown in his two letters to Pervukhin cited above.¹⁶

For instance, Kurchatov knew that "all the previously published research on 'uranium-moderator' systems was carried out in homogeneous mixtures of both these components." Writing to Pervukhin, he expressed his guess that the situation might be more favorable "if the system is heterogeneous, and the uranium is concentrated inside the mass of heavy water in blocks of the most appropriate size located at an optimal distance from each other." He went on: "I think our scientists must conduct a theoretical analysis of the comparative properties of homogeneous and heterogeneous mixtures of uranium with heavy water, and I am thinking of assigning the conduct of this analysis to professors Khariton and Zeldovich." And he immediately "tasked" Per-

vukhin: "It would be important to know . . . in what kind of a system—homogeneous or heterogeneous—experiments have been done." In the end, it was Gurevich and Isaak Pomeranchuk who successfully solved Kurchatov's problem, showing the decisive advantage of a heterogeneous reactor.

Although he regarded information obtained from intelligence sources cautiously, Kurchatov immediately noticed that there were, in his words, "some fragmentary comments about the possibility of using not only uranium 235 but also uranium 238 in a 'uranium boiler,'" and that "perhaps the products of nuclear combustion in the 'uranium boiler' may be used instead of uranium 235 as a material for the atomic bomb." In his March 22, 1943 letter to Pervukhin, he wrote: "With these comments in mind, I attentively looked through the latest research in *Physical Review* on transuranic elements (eka-rhenium-239 and eka-osmium-239) [neptunium and plutonium], and I was able to determine a new direction in the solution of the whole uranium problem. . . . *The prospects of this direction are unusually attractive.*" (Emphasis in original.)

Although Edwin MacMillan and Philip Abelson had reported the discovery of plutonium in 1940, its nuclear properties were still a mystery to Soviet physicists.^{19, 20} On the other hand, the fragmentary comments provided by intelligence sources about the possibility of using uranium 238 in a reactor and, perhaps, using the products of nuclear combustion for a bomb, were not conclusive enough for the decision that Kurchatov had to make. In the end, displaying impeccable physical intuition, Kurchatov decided on the long-term course by concluding: "According to all currently existing theoretical conceptions, the collision between a nucleus of [plutonium] and a neutron should be accompanied by a large release of energy and by emission of secondary neutrons. . . . It can be removed from the 'uranium boiler' and used for a [plutonium] bomb. The bomb will be made, therefore, from a 'non-earthly' material, which has disappeared from our planet. *As is apparent, this solution will obviate the need to separate uranium, which will be used both as a fuel and as an explosive.*" (Emphasis in original.)

Again, Kurchatov tolerated no delay: "The sketch that has been developed requires a quantitative calculation of all the details of the process. I will assign this work to Professor Zeldovich in the very nearest future."

"The patriotic impulse"

Thus, from its first day and its first steps, the Soviet atomic project had as its foundation the remarkable research of Soviet physicists, and

Beria could be the soul of courtesy and tact—when circumstances demanded it.

Kurchatov devised an absolutely correct program of implementation. But until 1945 this program was carried out by only a few researchers who had scarce resources. The project gained real momentum only after the first American atomic explosions. It was precisely at that time that the Soviet atomic industry and technology could be developed on a broad footing, with large installations and industrial combines.

It was exciting and extremely intense work, executed with great selflessness and enthusiasm. Kurchatov himself was the incarnation of the patriotic impulse in this unprecedented and responsible endeavor.

But for some reason this heroic enthusiasm is not always noticed and taken into account by contemporary researchers, who have emphasized the more unfortunate events and episodes that will happen in any large group. In a recent history of the Soviet atomic project published in Germany, the author claims that Arzamas-16 had an atmosphere of "gallows humor."²¹ He alleges that the workers were prone to extreme cynicism and alcoholism. The author has drawn a mere caricature—in fact, everyone was awed by the immensity of their task and fully aware of their duty.

There were no exceptional events that determined the atmosphere in the group—not even the peculiarities of the isolated life in a strict security zone. Of course there was little joy in watching the columns of prisoners who built the installation initially. But all that receded into the background, and people had little regard for the difficulties of everyday life—they were trying to achieve success in the best and quickest way. They knew that the country was in danger and they understood that the state was relying on them and giving them everything necessary for their work and their daily life. And they carried out their task splendidly.

Working for Beria

As we know, historical truth can be distorted not only by subjective accounts, but by excessive secrecy, which limits access to information, or by simple misunderstanding. Conjecture also abounds when the truth is hushed up for political reasons—as in the case of Lavrenti Beria. If there is no truth today, there will be myths tomorrow.

It is not our intention to reassess the crimes of this terrible man who caused immeasurable suffering. But until mid-1953, for about eight years, Beria had overall responsibility for all the work on the atomic project. In the interest of history, the facts of his administration should be known in more detail.

At first, the Soviet atomic project was ad-

ministered by Vyacheslav Molotov. His leadership style, and correspondingly, its results, were not terribly effective. Kurchatov did not hide his dissatisfaction.

Although Peter Kapitza, a participant in the activities of the Special Committee and the Technical Council on the Atomic Bomb, complained about Beria's methods in a letter to Stalin, once the project passed into Beria's hands, the situation changed completely.²²

Beria understood the necessary scope and dynamics of the research. This man, who was the personification of evil in modern Russian history, also possessed great energy and capacity for work. The scientists who met him could not fail to recognize his intelligence, his will power, and his purposefulness. They found him a first-class administrator who could carry a job through to completion. It may be paradoxical, but Beria—who often displayed great brutishness—could also be courteous, tactful, and simple when circumstances demanded it. It is no accident that Beria impressed Nikolaus Riehl, one of the German scientists who worked in the Soviet Union, very positively.²³

Beria's meetings were conducted in a business-like and fruitful way. They never lasted too long. And he was a master at finding unexpected and unconventional solutions. Gen. A. S. Alexandrov, who worked on Beria's staff and was later appointed Boris Vannikov's deputy at the First Chief Directorate, later became the chief of Arzamas-16. He cited one characteristic episode.²⁴ The Politburo decided to divide the Peoples' Commissariat of the Coal Industry, led by V. V. Vakhkrushev, into two parts—one for the western and one for the eastern regions of the country. It was assumed that the two would be headed by Vakhkrushev and D. G. Onika respectively. Beria had to oversee the division. You can imagine what a hassle this procedure would be if approached in the usual bureaucratic fashion.

Beria summoned Vakhkrushev and Onika and proposed that they arrange the division themselves. When the deadline came, he called them to his office. He asked Vakhkrushev, the candidate for director of the western regions, whether he had any complaints. Vakhkrushev replied that he had none, and that the division had been done properly. Then Beria turned to Onika: "What do you have to say?" Onika was prepared to be stubborn: "I do have complaints. Vakhkrushev took all the best people together with all the best sanatoriums and resorts." Faced with this situation, Beria declared: "If Vakhkrushev considers the division to be fair while Onika objects, we will do the following: Vakhkrushev will be the People's Commissar of the East, and Onika of the West." And that was the end of that meeting.

Mikhail Sadvovskii had quite a different

meeting with Beria.²⁵ Beria met with about 30 people in his Kremlin office to discuss the preparation of the test site for the first thermonuclear explosion. Those making reports were trying to say where the equipment should be located, what kind of structures should be erected and how, and what kind of experimental animals should be placed at the site to study the impact of the blast effects. Suddenly, Beria became incensed. He interrupted angrily, moving from one briefer to another, asking strange questions which were not easy to answer.

Finally, Beria completely lost his temper. He screamed: "I will tell you myself!" Then he started to talk nonsense. It gradually became clear from his stormy monologue that he wanted everything at the test site to be totally destroyed in order to provide the maximum terror.

After the meeting, the participants left in a gloomy mood. Sadvovskii realized for the first time that dealing with Beria was no joke.

Beria was a quick worker, and he visited all the installations to acquaint himself personally with the results of the work. During the first atomic explosion he was the chairman of the state commission. Despite his exceptional position in the party and the government, Beria made time for personal contacts with people who interested him, even those without official distinctions or titles. On a number of occasions he met with Andrei Sakharov, who was then merely a Candidate of Physical and Mathematical Sciences, as well as with Lavrentiev, who was a recently demobilized sergeant from the Far East.

If the project needed some specialist that Beria's *apparatus* deemed unacceptable, he was willing to make an exception. When the security service wanted to remove Altschuler on the grounds that he was unreliable—he was a critic of Trofim Lysenko's genetic theories—Khariton telephoned Beria directly and told him that the project needed Altschuler. After a long pause, Beria asked a single question: "Do you need him very much?" After receiving a positive response, Beria said "All right," and hung up. The incident was closed.

Many atomic industry veterans believe that if the project had remained under Molotov's leadership, such quick success in carrying out work of such immense scale would not have been possible.

"On a Russian scale"

Joseph Stalin also paid personal attention to the atomic project, as demonstrated by Kurchatov's notes of his one-hour meeting with Stalin in the evening of January 25, 1946, which have been preserved.²⁶ The meeting was

Kapitsa on Beria

Peter Kapitsa, a prominent Soviet physicist who was awarded the Nobel Prize in 1978 for his work in low-temperature physics, worked at Cambridge University from 1921 to 1934. During a trip to the Soviet Union in 1934, he was called to Moscow and forbidden to return to England.

Soon after the bombings of Hiroshima and Nagasaki in 1945, the Soviet Union formed the Special Committee and the Technical Council on the Atomic Bomb, and Kapitsa, then head of the Institute of Physical Problems, was appointed a member. In an October 3, 1945, letter to Stalin he complained about Beria's behavior. Beria's relationship with scientists was, he said, "intolerable," and he asked to be allowed to resign from the committee.

By November 25, his relationship with Beria had worsened. He wrote again: "Comrades Beria, Malenkov, and Voznesensky conduct themselves in the Special Committee as if they were supermen. Especially Comrade Beria. To be sure, he holds the baton in his hands. This is not bad, but the scientist nonetheless should play first violin. . . . Comrade Beria's basic weakness consists in the fact that the conductor must not merely wave the baton, but also understand the score. In this Beria is weak. . . .

"Things are not working out at all between Beria and me. His attitude toward scientists, as I've written you earlier, goes against the grain. . . .

"My continued presence on the Special Committee and the Technical Council, you yourself can see, is fruitless and only oppresses me greatly and interferes with my scientific work. Inasmuch as I am a participant in this matter, I naturally feel responsible for it, but to make things proceed as I would wish is beyond my strength. Indeed this would be impossible, since Comrade Beria, as most of the comrades, does not sanction my objections. . . .

"My relations with Comrade Beria have grown worse and worse; he undoubtedly will be pleased with my departure."

Kapitsa was released from the Special Committee. In the spring of 1946 he was also dismissed from his job as head of the institute.

—Linda Rothstein

also attended by Molotov and Beria.

In the course of the conversation Stalin rejected small-scale projects and cheap solutions. He stressed that it was necessary to act "on a broad front, on a Russian scale" and that in this respect all-round help would be provided. Stalin said that Soviet scientists were very modest people, and that "sometimes they do not notice that they live badly."

According to Kurchatov: "In relation to scientists, Stalin was concerned how to improve the material conditions of their lives and [that they be given] prizes for major achievements—for example, for solving our problem. . . . It was proposed [that I] write a report about the measures necessary to speed up the work, everything that was needed."

Shortly before the first explosion of the atomic bomb, the directors of the basic areas of research concerning the preparations for

A lively interest in science history?

A robbery late last year at the Moscow apartment where Igor Tamm once lived suggests that there is still a lively interest in Russian scientific history.

Tamm, a famous nuclear physicist who died 21 years ago, won many awards, including the Nobel Prize in physics. Today, Tamm's grandson and his family live in the apartment, which contained an extensive collection of scientific memorabilia, including Tamm's correspondence with colleagues from around the world.

The robbers not only knew the apartment well, they also knew exactly what they wanted. They rang the bell, and immediately hit the grandson's wife on the head, knocking her unconscious. Then they broke open the door to the locked archive. Within 20-30 minutes they had managed to search through piles of papers stored in several suitcases and remove letters from—among others—Albert Einstein, Werner Heisenberg, and Max Born. Also stolen were an autographed photo of Andrei Sakharov and a gold Lomonosov medal, which is the highest award given by the Academy of Sciences. When the grandson's wife regained consciousness, her head was wrapped in a trench coat. She said that the robbers were whispering to one another, perhaps so she would not recognize their voices. She heard enough to realize that the main object of their search was the Nobel Prize medal, but it was kept in another place.

The Moscow police could not recall the last time that thieves passed up valuables such as antique silver, electronic equipment, and expensive clothes, all of which are difficult to obtain in Russia. It also seems unlikely that the thieves could have sold the letters in Russia—it would be nearly impossible to find an interested party. All this suggests that the goal of the robbery was to sell the loot to wealthy collectors abroad.

Investigators believe that a scientist may have planned the robbery. They think it was someone who frequented the apartment, and who was probably planning to move to the West.

Perhaps the robbery of Tamm's apartment was an extension of Russia's "brain drain" problem in its most radical form. According to research done by the Institute of the History and Methods of Natural Science, about 80 percent of scientists who work within the Academy of Sciences system definitely would like to move to the West. In some institutes, especially those that concentrate on physics and mathematics, about 80 percent of actively working experts have already left. For example, in the laboratories of the famous Physics Institute where Tamm once worked, 15 of 20 researchers have Western contracts, and they come back to Russia only on occasion. With so many people departing, it would be surprising if some persons of unsavory character, who would not be squeamish about criminal acts, were not among them.

Igor Tamm's apartment was robbed at the end of 1992. The Moscow Criminal Investigation Department, swamped with other, more serious crimes, was not able to give much attention to the theft. In February 1993 the Chief of the Police Department, A. Antonov, told me that he believed that the stolen items had already been shipped abroad, and that the police had contacted Interpol.

—Sergei Leskov

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the test reported to Stalin himself, with Beria and Kurchatov in attendance. The specialists were invited to Stalin's office one by one, and Stalin attentively listened to each. The first report was delivered by Kurchatov, followed by Khariton and the others.

This was Khariton's only meeting with Stalin. Stalin asked Khariton: "Couldn't two less powerful bombs be made from the plutonium that is available, so that one bomb could remain in reserve?" Khariton, who knew that only the precise amount of plutonium required for the American-designed weapon was available and that taking any additional risk would be unacceptable, responded negatively. Contrary to legend, no plutonium sphere was shown to Stalin nor did he touch one during this report. (From the place where it was produced, Chelyabinsk-40, the plutonium sphere was taken first to Arzamas-16, and then transported directly to the Semipalatinsk test site.)

The legend of Stalin's having been presented with a plutonium sphere was apparently composed by members of Beria's staff, where the dialogue between Stalin and Khariton was combined with an episode recounted by Anatoli Alexandrov.²⁷ Alexandrov was at Chelyabinsk-40, covering the plutonium hemispheres for the first bomb with nickel coating:

"I was sitting one night doing that. All of a sudden a whole group of generals arrived. They started to ask where I had got the hemisphere, and was it really plutonium, and not just a piece of metal. I told them: look at it, it is warm. It is radioactive and it warms itself. Gradually I persuaded them that it was indeed plutonium."

According to M. G. Pervukhin, early in October 1949, after the explosion of the first bomb, Kurchatov and other members of the commission reported the results to Stalin. Stalin was interested in details, and he asked the speakers several times whether they had personally seen what they were reporting.

Rewarding work

On October 29, 1949, two months after the explosion of the atomic bomb, Stalin signed a secret decree that was issued by the Council of Ministers of the Soviet Union. Few people—other than those who received awards—know its text. And the award winners were informed only in separate, personal excerpts, so that they would not see the entire document. In this decree, several particularly distinguished participants in the research, led by Kurchatov, were named "Hero of Socialist Labor," awarded bonuses, and given ZIS-110 or Podeda cars, the title of the Stalin Prize Laureate of the First Degree, and dachas. Their children were to receive a free educa-

tion in any educational establishment at state expense. The recipients and their wives were awarded free and unlimited transportation by rail, air, and water, anywhere in the Soviet Union, for as long as they lived, a privilege shared by their minor children. The right to free travel was later abolished by Nikita Khrushchev.

Veteran scientists say that Beria, when deciding which prizes to award, used a simple principle that was not without a certain malicious humor: Those who in case of failure would have been shot were to receive the title of Hero; those who would have been given the maximum prison term were to be awarded the Order of Lenin, and so on down the list. It is hard to say whether these rumors correspond to the truth or are an example of "folklore."

On the other hand, General Alexandrov calmly recalled the preparation of the documents for the awards in an entirely different manner.²⁸ "Beria instructed me to prepare a draft of the decree of the Council of Ministers of the Soviet Union on measures to encourage the development of questions of atomic energy. . . . While working on the draft I thought of the following: what are these comrades going to do with the money—you couldn't buy anything with it in our conditions! I went to Beria with this question. He listened to me and said: 'Take a note—we will build fully furnished dachas for them at state expense. We will build cottages or give them apartments, whichever they wish. We will give them cars.' In general, what I proposed that they should be allowed to buy was provided at state expense. The draft was approved."

Fear of failure

The burden of responsibility that rested on the shoulders of the creators of Soviet nuclear weapons was no laughing matter. The scientists all felt the prickly chill of possible retribution when a device "refused" to work, as the bomb makers say, and the nuclear explosion did not take place. The first such "refusal" took place, fortunately, on October 19, 1954, after our country already possessed atomic and thermonuclear weapons, and Beria was no longer alive.

Negin recalls it well.²⁹ "After Kurchatov, Malyshev, Zernov, Khariton, and other participants visited the site of the failed atomic explosion, we gathered in the bunker and began calmly trying to understand the causes of the failure. Suddenly, a colonel from state security appeared. Spick and span, with a service cap on his head, he saluted and addressed Vyacheslav Malyshev, our minister:

"Comrade Minister, if I understand correctly, there was a failure?"

"That is correct."

"Please allow me to start an investigation."

"We all felt uncomfortable. Malyshev calmly began to speak:

"You see, we are dealing with science here. Not war. These are new things, we don't know everything yet. The scientists are getting to the bottom of it. They also cannot say right now what the cause was."

"So allow me to start an investigation!"

"The color of Malyshev's face started to change slowly. He turned red.

"I tell you, this is an experimental thing, made for the first time. Apparently, we were unlucky in some way and we failed. But I think that we will sort it out in a short time and find the answer."

"So allow me to start an investigation!"

"Malyshev turned purple with rage, then said:

"Get out!"

"The colonel saluted again, turned on his heels, and went away."

The failure of a device to explode was always a difficult trial for those who developed it. Even a man as full of jokes and humor, as cheerful by nature as Yakov Zeldovich, felt such failures very sharply.

The first hydrogen bomb

Today, many people realize that it was Soviet physicists who first developed thermonuclear weapons. We began by trying to catch up with our American colleagues, who created the atomic bomb in mid-1945. By August 1949, the dangerous U.S. monopoly on atomic weapons was eliminated. Then, Soviet physicists took the lead, and on August 12, 1953 they were the first in the world to explode a real hydrogen charge, which was ready to be used as a bomb. The idea for that device belonged to Andrei Sakharov.

It is true that American scientists carried out a thermonuclear explosion on November 1, 1952, but this experiment was only a step on the way to the creation of a true hydrogen bomb. The U.S. device was a huge, immobile 50-ton, land-based building the size of a two-story house.³⁰ The nuclear fuel contained inside it had to be cryogenically condensed. Soviet scientists managed without this kind of very complicated and costly experiment.

The United States took the lead in improving hydrogen weapons in 1954. But by 1955, Soviet physicists had made a genuine technological breakthrough, neutralizing the Americans' success. The designers of this new weapon were Sakharov, Zeldovich, and Yuri Trutnev. Moreover, Soviet scientists were the first in the world to explode a hydrogen bomb dropped from an airplane. This experiment



Andrei Sakharov, who developed the Soviet A-bomb.

LEONID TITMAN

Americans underestimated the significance of the August 1953 Soviet hydrogen bomb test.

took place on November 22, 1955, and was carried out by a crew commanded by Hero of the Soviet Union F. P. Golovashko. The first air-drop of an atomic bomb in the Soviet Union took place on October 18, 1951; the air crew was commanded by Hero of the Soviet Union Lt.-Col. K. I. Urzhuntsev.

On October 30, 1961, Soviet physicists detonated a 50-megaton bomb, which remains unsurpassed in terms of its yield. This device was distinguished by its purity: 97 percent of its energy yield was derived from thermonuclear reactions. The complete success of this test proved that it was possible to design devices of virtually unlimited power on the basis of the principle proposed by Sakharov, Viktor Adamskii, Yuri N. Babaev, Yuri Smirnov, and Yuri Trutnev. The bomb was exploded at an altitude of four kilometers over Novaya Zemlya, using a Tu-95 strategic bomber piloted by Hero of the Soviet Union A. E. Durnovtsev.

While outstanding individual achievements have been noted, the most important element in the program was the tremendous creative work of remarkable teams of physicists and development engineers at Arzamas-16 and Chelyabinsk-70, which led to the creation of a powerful nuclear defense shield. The success of the endeavor was a result of the close collaboration of scientists with designers, engineers, and industrialists—all masters of their trades.

In the December 8, 1992 issue of *Izvestia*, we made clear that the Soviet hydrogen bomb was created completely independently and was in no way a product of the activity of Soviet intelligence. American scientists have also concluded that Klaus Fuchs could not have transmitted the secret of the hydrogen bomb to the Soviet Union—because at the time Fuchs was communicating information to the Soviet Union, American nuclear physicists' research in this area was mistaken and unsuccessful.

Some physicists in the United States have asserted—because of a lack of information—that the Soviet hydrogen bomb tested on August 12, 1953, was not a “real” hydrogen bomb.³⁰ They have also claimed that Soviet physicists could have acquired critically important information for the creation of the 1955-model hydrogen bomb by analyzing fallout from the U.S. explosion on November 1, 1952.

First, as to whether the Soviet hydrogen bomb, exploded on August 12, 1953, was “real” or not: The effectiveness of a thermonuclear design is, to a significant degree, determined by the degree of compression of the thermonuclear fuel that is provided by the initial explosion of the atomic device. Admittedly, the two Soviet hydrogen bombs tested in 1953

and 1955 were indeed different. But the yield of the bomb tested in 1953 was 20 times greater than that of the bomb dropped on Hiroshima, yet it had the same dimensions and weight. For that reason alone, the tested charge was a major step in the development of nuclear weapons. Moreover, the design of the device would have made it possible to create a hydrogen bomb on the order of one megaton. The “thermonuclearity” of the charge—the contribution of thermonuclear reactions to the total value of the yield—was an important indicator. This indicator was in the area of 15 to 20 percent.

Some American specialists have compared the Soviet test in 1953 with tests they conducted (the “George” type) in 1951.³¹ These U.S. tests used small amounts of tritium and deuterium to show, in Herbert York’s words, that “the thermonuclear reaction under ideal conditions can take place in an experimental device.” But such experiments, as noted by American physicist Robert Jastrow, were “more a way to impress the public than a real experiment. . . . The use of a large atomic bomb to initiate a reaction in a small bubble with deuterium and tritium was like using a blast furnace to light a match.”³² The Soviet device tested on August 12, 1953, was in a different class.³³ It used a more promising fuel—lithium deuteride, which was not employed in American devices until later. In the Soviet device, tritium was produced in the course of the thermonuclear reactions during the explosion, and the high-energy neutrons produced the “fission-fusion-fission” effect. This “three-step” process is essential to modern thermonuclear weapons.

American colleagues have clearly underestimated the significance of the Soviet test in August 1953, which must be considered the first test in the world of a hydrogen bomb.

Finally, did Soviet scientists use information acquired as a result of radiochemical analyses of atmospheric samples after the U.S. test on November 1, 1952?

Definitely not. At that time, Soviet research was not organized on a sufficiently high level, and useful results were not obtained, although radiochemical analyses of samples of fallout could have provided some useful information about the materials used to produce the explosion. The relationship between certain short-lived isotopes formed in the course of thermonuclear reactions could have made it possible to judge the degree of compression of the thermonuclear fuel, but knowing the degree of compression would not have allowed Soviet scientists to conclude exactly how the exploded device had been made, and it would not have revealed its design.

In any case, Gurevich, Zeldovich, Pomeranchuk, and Khariton originally proposed the

use of thermonuclear reactions to create a bomb in 1946, and had already come to the conclusion that "it is desirable to achieve the highest possible density of deuterium, and this can be achieved with its use under high pressure."¹⁴ They also proposed the use of uranium charges to initiate the explosion. Even if Soviet scientists had acquired information from analyzing fallout, it would not have revealed anything new.

Hitler's fault

Looking back, we know that one of the initial impulses for both the U.S. and Soviet atomic projects was the fear that Nazi Germany, which before the war possessed the most advanced and modern technologies and first-class science, might create atomic weapons. Hitler's declarations about weapons of retribution sounded sinister. After World War II, nuclear weapons became the basic argument in the extremely dangerous confrontation between the world powers. As we gradually free ourselves from the legacy of confrontation, we can now see that in the late 1940s and early 1950s nuclear physicists—including the brilliant constellation of Soviet physicists headed

by Igor Kurchatov—did something greater and more lasting. They opened the door to a new era. In this era, atomic energy not only defines the technological level of society, it also influences culture, politics, and the future. Consequently, it influences history. This is particularly clear if one remembers the work of Ida Noddack, published in a German applied chemistry journal in 1934.¹⁵

Ida Noddack doubted Enrico Fermi's interpretation of his experiments in which he irradiated uranium with neutrons. She thought that what in fact was happening was not the formation of "transuranics," but the fissioning of the heavy atomic nucleus of uranium into parts. She even sent her article to Fermi, but he rejected her point of view.¹⁶ In 1936, Otto Hahn called her suggestion about the decay of uranium absurd.¹⁷

It is frightening to think how different events might have been if the true worth of this prophetic article—which preceded the Hahn and Strassman discovery of the fissioning of uranium by more than four years—had been immediately recognized in Nazi Germany. Hitler could have been the possessor of the atomic bomb, and the outcome of World War II would have been entirely different. ■

1. Robert Jungk, *Brighter Than a Thousand Suns: A Personal History of the Atomic Scientists*, trans. James Cleugh (New York: Harcourt Brace, 1956), p. 63.

2. Otto Hahn and Fritz Strassman, *Die Naturwissenschaften*, vol. 27 (1939), p. 711.

3. Arnold Kramish, *The Griffin* (Boston: Houghton Mifflin Co., 1986).

4. *Delovoi Mir*, no. 211 (October 31, 1992), p. 11.

5. Interview with author.

6. *Izvestia* (December 8, 1992).

7. *Voenno-istoricheskiy zhurnal*, no. 1 (1991).

8. John F. Hogerton and L. Raymond, *Kogda Rossiia budget imet' atomnuuiu Bombu?* (Moscow, 1948), p. 36.

9. Max Steenbeck, *Impulse und Wirkungen: Schritte auf meinem Lebensweg* (Berlin: Verlag der Nation, 1977), pp. 158–159.

10. A. T. Ioyrich, *O chem zvuut kolokol* (Moscow, 1992), pp. 62–64.

11. Yakov B. Zeldovich and Yuli B. Khariton, *Zhurnal Eksperimentalnoi i Tekhnologicheskoi Fiziki*, vol. 9, no. 12 (1939), pp. 1425–1427; vol. 10, no. 1 (1940), pp. 29–36; vol. 10, no. 5 (1940), pp. 477–482.

12. Lev Rusinov and Georgi N. Flerov, *Izvestia Akademii Nauk SSSR, seriya fizicheskaya*, vol. 4, no. 2 (1940), pp. 310–314.

13. K. A. Petzhakh and Georgi N. Flerov, *Dannye Akademii Nauk SSSR*, vol. 28, no. 6 (1940), pp. 500–501.

14. Igor V. Kurchatov, memo to file, Kurchatov Institute Archives, Moscow.

15. Yakov B. Zeldovich and Yuli B. Khariton, *Uspekhi fizicheskikh Nauk*, vol. 139, no. 3 (1983), p. 513.

16. *Khimia i zhizn*, no. 6 (1985), p. 19.

17. *Khimia i zhizn*, no. 3 (1985), pp. 6–10.

18. *Viprosi istorii yestestvoznaniia i tekhniki*, no. 3 (1992), pp. 111–118.

19. Edwin McMillan and Philip Abelson, *Physical Review*, vol. 57 (1940), pp. 1185–1186.

20. L. A. Turner, *Physical Review*, vol. 58 (1940), pp. 181–182.

21. Andreas Heinmann-Grüder, *Die sowjetische Atom-bombe* (Berlin: Berghof-Stiftung für Konfliktforschung, 1990), pp. 129–135.

22. Peter L. Kapitza, *Pisma o nauke: 1930–1980*, (Moscow: Moskovskii Rabochi, 1989), pp. 237–247.

23. Nikolaus Riehl, *10 Jahre im goldenen Käfig. Erlebnisse beim Aufbau der sowjetischen Uran-Industrie* (Stuttgart, 1988), pp. 37–45.

24. Interview with author.

25. Interview with author.

26. Igor Kurchatov, notes of meeting with Joseph Stalin, no. 185, Kurchatov Institute Archives, Moscow.

27. Interview with author.

28. Interview with author.

29. Ralph Lapp, *Kill and Overkill* (New York: Basic Books, 1962), p. 43.

30. Hans Bethe, "Nuclear History: Sakharov's H-bomb," *The Bulletin of the Atomic Scientists* (October, 1990), pp. 8–9; Daniel Hirsch and William G. Matthews, "The H-bomb: Who Really Gave Away the Secret?" *The Bulletin of the Atomic Scientists* (January/February, 1990), pp. 22–30; *Uspekhi fizicheskikh Nauk*, vol. 161, no. 5 (1991), pp. 153–169.

31. Herbert F. York, *The Advisors: Oppenheimer, Teller and the Superbomb* (San Francisco: W. H. Freeman, 1976), p. 77.

32. Robert Jastrow, "Why Strategic Superiority Matters," *Commentary*, vol. 75 (March, 1983), p. 27.

33. V. I. Ritus and Yu. A. Romanov, *Priroda*, no. 8, (1990), pp. 10–24.

34. Isaak Gurevich, Yakov B. Zeldovich, Isaak Pomeranchuk, and Yuli B. Khariton, *Uspekhi fizicheskikh Nauk*, vol. 161, no. 5 (1991), pp. 170–175.

35. Ida Noddack, *Angew. Chemie*, vol. 47 (1934), p. 653.

36. Emilio Segrè, *Enrico Fermi: Physicist* (Chicago: University of Chicago Press, 1970), pp. 105–106.

37. Friedrich Herneke, *Bahnbrecher des Atomzeitalters* (Berlin: Buchverlag Der Morgen, 1970), pp. 335–336.

RUSSIAN SCIENTISTS SAVE AMERICAN SECRETS

By ROALD SAGDEEV

Who would have thought the KGB would want to spill the beans?

Many fear that the collapse of the Soviet Union has created new opportunities for would-be nuclear proliferators. The West has voiced concern over potential nuclear blackmail in inter-ethnic conflicts, the possibility that nuclear materials will be smuggled out of the country, or that there will be a nuclear brain drain to one of the hostile regimes in the Middle East.

Until recently, those dangers have seemed mainly theoretical. However, the former Soviet world was recently on the brink of breaching the Nuclear Non-Proliferation Treaty (NPT)—but the danger came from a completely unexpected corner—the KGB.

Russia's files on early Soviet nuclear espionage activities in the United States were about to be opened. A scientific journal was within a wink of printing documents that at first seemed relevant only to historians, but which could have contained secrets useful to countries currently trying to develop a basic nuclear bomb.

It is ironic that such "openness" should come from the former Soviet state. The Russians were always strict keepers of secrets in

general. Particularly in the nuclear area, the Soviet Union had very tightly regulated systems of secrecy. These traditions were introduced by chief KGB hangerman and nuclear program supervisor, Lavrenti Beria.

Thus it is even more ironic that the move to open a portion of the old nuclear-espionage archives came not from democratic or liberal circles but from the KGB itself. According to those involved in the drama, the driving motive for KGB officials to reveal the history of nuclear espionage was their desire to "restore" their rightful place in history as the true "heroes of the Soviet nuclear miracle."

The KGB was deeply involved in efforts to steal American secrets, and, in the last analysis, it felt that its contribution to the Soviet bomb program had not been sufficiently appreciated. These feelings have been revealed in remarks made in recent interviews by a number of former intelligence officers, including the former chief Soviet spy in New York, Lt. Col. Anatoly Iatskov.

For his invaluable service to the state—providing the sketch of the first American bomb—Comrade Iatskov was, in the end, rewarded only with the "Combat Red Banner Order." This state prize ranks some grades below the awards given to leading Soviet nuclear scientists. Half a dozen of them—including Igor Kurchatov, the head of the country's nuclear team, and his closest associates, Yuli Khariton and Yakov Zeldovich—were three

Roald Sagdeev, a professor of physics at the University of Maryland and director of the East-West Space Science Center, is a member of the Bulletin's Board of Directors. He was formerly director of the Institute of Space Research in the former Soviet Union.

times declared "Heroes of Socialist Labor," the country's highest honor. (They rank second only to Leonid Brezhnev, who awarded himself five "Heroes.") A number of other scientists were elected to specially created vacancies in the Academy of Sciences for their "outstanding contribution in special fields important for national security."

The desire for credit for the Soviet nuclear program coincided with the end of the Cold War—a time when the KGB as an organization was also in transition. About two years ago, the ultra-patriotic press, which is close to the Russophile *Pamyat* society, published a number of articles in literary magazines like *Molodaya Guardia*, claiming that the true saviors of the country were courageous Russian spies, not physicists who, by definition, were not genuine Russian patriots—because physics is "a Jewish science." This theory, in its most extreme form, was explained by Nikolai Alexandroff in *Soyuz*: "There was no 'Russian' atomic bomb. There was only an American one, masterfully discovered by Soviet spies." The political message of these articles was obvious. They were an attack on the liberal scientific intelligentsia, the engine of the democratic revolution in the Soviet Union.

As dramatic as these attacks were, the KGB could not prove its case. The files containing the biggest secret of the century remained closed, despite the eagerness in KGB circles to see them open.

But more recently, a sweeping campaign to open the Kremlin and Communist Party archives offered the KGB another chance. Instructions were issued—probably within the KGB apparatus—and top-secret documents were given to the Institute of the History and Methods of Natural Science, the most qualified historians of science in Moscow. (One can only imagine the researchers' joy when they were suddenly given such a "czar's present.") In an interview, Dr. Igor Golovin, Deputy Director of the Kurchatov Institute from 1944 until 1960, told me that the atomic archives contained about 300 documents dating from 1942 to 1949.

The material was of varying interest, although the historians had more than enough to digest. When they had finished, everyone on the team looked forward to the reward most cherished by all the scholars—the publication of their work in a scholarly journal. The institute had its own, called *Issues in the History and Methods of Natural Science*.

It was sheer chance that the final galley proofs of such an historic issue of the magazine found their way into the hands of a few physi-

cists, including Golovin. Golovin had been a close collaborator and assistant to Igor Kurchatov, father of the Soviet A-bomb. As Kurchatov's assistant, Golovin knew a lot about the material, but he was surprised to see the full set of documents. During the bomb program, only three people had unlimited access to the file: Stalin, Beria, and Kurchatov.

The work on the bomb had been performed through a highly compartmentalized management structure. Each participant in the nuclear program had the right to know only as much as needed to perform his task. In effect, the trio, who had access to everything, had introduced an unspoken code of internal nonproliferation.

Kurchatov used American materials for the dual purpose of double-checking the scientific results obtained by members of his team, and for evaluating the probability that the stolen secrets might contain purposely planted disinformation. Inside the Russian nuclear establishment legends were told of how his subordinates—the theoretical physicists—would report to Kurchatov with freshly calculated formulas. According to their accounts, Kurchatov would look carefully at their work, then silently open the safe with the precious stolen American secrets to compare the results. "No, it is not right," he would say. "You have to work more and come again."

A few physicists were entitled to familiarize themselves with selected clips from the American documents, but only if the documents were relevant to their roles in the program. Lev Artsimovich, one of the big names in Soviet physics of that period, was introduced to American materials on electromagnetic isotope separation. Isaak Kikoin, the experimental genius of Kurchatov's team, had access to documents on centrifugal isotope-separation technology. Eventually, Kikoin and his co-workers were able to raise that technology to a level that is believed to be the best in the world.

So, what was at stake in this attempt to publish the archives? It was not only the prestige of physicists versus that of KGB agents, it was also the risk of nuclear proliferation.

Some skeptics say there are no more secrets, that too much was published during the year. But the Russian physicists were right to act with extreme prudence. If there is even a small chance that their actions will complicate the efforts of some countries to join the nuclear club, it was worth following a "worst case" scenario. The papers could have been useful to any aspiring nation. Information on the first bomb might have provided valuable clues to

There could not have been a homegrown bomb because physics is considered "a Jewish science."



PHOTOS: AP/WIDE WORLD

Only Joseph Stalin and Lavrenti Beria (above)—and Igor Kurchatov, head of the bomb program—had access to all the stolen secrets.

bomb development. In fact, the older the design, the easier it would be to reproduce it somewhere in the Third World. Someone like Saddam Hussein would love to have these materials.

Once they understood what was about to be published, the Russian nuclear physicists at Arzamas-16 triggered another chain reaction, this time in communication between government offices. Golovin, stunned by the amount of formerly top-secret material prepared for publication, phoned Yuli Khariton, the recently retired scientific director of Arzamas-16, the Soviet counterpart to the Los Alamos National Laboratory. Still influential despite his 88 years, Khariton understood immediately how explosive the galley proofs were. He telephoned the Minister of Atomic Industry, Victor Mikhailov, a former member of the Arzamas team, and the final decision was made to halt publication. In the end, the formal instructions to cancel the issue were conveyed by the Russian Foreign Intelligence Service.

Although their intervention stopped the publication of the technical papers, it was too late to prevent the fuss about nuclear espionage. According to Golovin, the embarrassed historians, who anticipated a publishing sensation, had sent copies of the galley proofs to some newspapers, including the *Washington Post*.

In order to minimize the damage, Russian authorities quietly approached the newspapers, asking them not to print the materials because they might promote nuclear proliferation. Final newspaper stories did indeed omit technical details; instead, the accounts of Iatskov and his comrades-in-arms from the Soviet intelligence network were featured prominently. They did not say much, however, about the names of their American helpers; this part had been censored by the KGB from the very beginning.

Now that the files have been returned to the archives where they are inaccessible to emerging nuclear powers, it is interesting to revisit the old mystery of the impact that stolen plans had on the pace of the Soviet nuclear program. The late Andrei Sakharov—another triple “Hero of Socialist Labor” for the design of the hydrogen bomb—was always skeptical about the importance of espionage. “There was only one secret: that it is possible to make the nuclear bomb,” he once told a gathering at my institute. Artsimovich, on the other hand, estimated that the stolen materials saved the Soviets about a year.

Western leaders may have learned something about espionage from their own experience. Harry Truman and Winston Churchill had prepared a special psychological experiment during the summit in July 1945. But not

a single nerve betrayed Joseph Stalin’s calm when they told him about the first test of a nuclear bomb, a weapon that dwarfed everything that had been invented or built before.

One of the articles set for publication may explain Stalin’s seeming indifference. It described the central document in the file, which allegedly contained a complete sketch of the first American plutonium bomb, code-named “Trinity,” that was exploded on July 16, 1945, in the desert near Alamogordo, New Mexico. Truman did not know that Stalin knew the secret of that bomb before he did; Truman was briefed on the bomb only after he became president in April 1945.

The first Soviet fission bomb, exploded in August 1949, was a plutonium bomb, as was the Trinity bomb. Was it a coincidence? It is not obvious that Khariton—then the scientific director of Arzamas-16, where the bomb was designed and assembled—had ever seen the complete file of American blueprints before. Forty-seven years later, with the galley proofs in his hand, he had to make up his mind whether or not these materials should be published.

The small part of the story that had been leaked to the press created pressure on the Russian authorities to explain more, and it was also a challenge to the nuclear establishment to defend its historic role in making the Soviet Union a nuclear power. Officials may have felt they had to come up with something for public consumption. After a few weeks of hesitation and preparation, in November 1992 the first Russian TV channel came up with a program that offered what may be considered the official version of the “making of the Russian bomb.”

After the narrator said, “Now we have come to the extremely delicate subject of who stole atomic secrets from whom,” Academician Yuli Khariton himself appeared on camera: “Some comrades in the press and on television claim that nobody invented anything in the Soviet Union, that Soviet scientists had everything handed to them on a plate by intelligence agents.”

Then more comments from the narrator: “Klaus Fuchs, a talented physicist who had emigrated from fascist Germany, handed over extremely valuable information to Soviet intelligence. Thanks to him, our country was able to speed up its own program by at least two years. Let us also give due credit to other eminent American scientists, who from the very beginning of their work insisted that atomic research had to be coordinated with the Soviet Union. Klaus Fuchs certainly did not seek material advantage by handing over information. He was convinced that a monopoly on the bomb would provoke its use.”

It was the first time that an authoritative assessment of the effect of having the American materials had ever been given—that it had speeded up the Soviet program by “at least two years.” And the assessment had come directly from Arzamas-16. Khariton did not deny that in preparing the first plutonium bomb exploded on Soviet territory, the Russian team had tried to stay as close to the stolen American recipe as it could. This was dictated, he said, by the highest considerations of national security, and the need to have the weapon as soon as possible.

Col. A. Feklisov, who apparently served as Klaus Fuchs’s KGB liaison officer, has complained that his “source” did not receive sufficient recognition (*Military-Historical Journal*, 1991). “After the successful test of the first Soviet atomic bomb, our leading scientists were decorated. . . . Some awards were given also to a few intelligence officers. Unfortunately, Klaus Fuchs had got 14 years of imprisonment—and nothing else.”

A proposal to make Fuchs a foreign member of the Soviet Academy was rebuffed. According to German Smirnov (*Molodaya Guardia*, No. 3-4, 1992), M. Keldysh, then president of the academy, said: “It is not sensible, since it could cast a shadow on the contribution of Soviet scientists.”

The Soviet Academy was often forced to accept members who were not scientists or engineers, merely Marxist ideologues from the highest echelons of power. But to elect Fuchs, whose scientific contribution to the American nuclear program was probably rather modest, would have required a change of the academy’s charter to include a new genre of activity. Perhaps the other American spy, “Perseus,” who Iatskov claims was a more important figure inside the Manhattan Project, would have been a more serious challenger, but his identity is still a KGB secret.

The question of science versus espionage also touched the origin of the hydrogen bomb. Here, too, Iatskov gave the credit to the intelligence community’s “comrades.” (The ultra-patriotic press had already dismissed Andrei Sakharov as the creator of the H-bomb.)

In the November 1992 TV show, Khariton categorically rejected the KGB’s claim: “In the final analysis, the eventual prototype of the [two-stage] H-bomb, on which all modern nuclear weapons are based, stemmed from our own work—the Americans were first to test this weapon in 1954, as we tested our own in 1955. But we worked completely independently.”

Although the secrets remain tightly kept by Russian authorities, one can try to uncover the nuances of these controversies by examining the testimony of a few key players. The logic of my own investigation runs like this:

Lt. Col. Iatskov admits that all American helpers abruptly stopped cooperating with the Soviets after August 1949. Apparently they considered the successful Soviet atomic test as the complete fulfillment of their “moral” duty to help the Soviets attain nuclear parity. Still, Iatskov insists that he had enough time to pass the secret of the future H-bomb to the Kremlin.

Andrei Sakharov, who joined the design team in 1948, discovered that the first approach the Soviets took to the H-bomb was wrong. In his *Memoirs* he related it to an early American idea, stolen by the KGB, which was later dismissed as completely erroneous. Iatskov may have gotten his hands on Edward Teller’s early, unsuccessful proposals. Sakharov describes the massive but futile attempts of the Arzamas team to pursue this approach until he came up with a real breakthrough—a completely different idea.

In the case of the H-bomb, the efforts of Soviet intelligence agents were clearly counterproductive. Perhaps this should be a source of relief. If the KGB were to insist on declassifying all the files, the publication of what they think is the American H-bomb secret would probably not do much harm.

By now, the hot debate over the source of Soviet nuclear weapons is close to exhaustion. Both sides have expressed their views in numerous publications and interviews. It is clear that, even if stolen materials were of significant help in making the first Soviet weapons, the Soviet program later produced a genuinely home-made product that culminated in 1953 with the first original test of a “real” hydrogen bomb, even before similar tests in the United States.

Khariton’s frank account, and the physicists’

Thanks to the KGB, Stalin knew about the U.S. bomb program before Truman did.

Igor Kurchatov (center), during a 1956 visit to the Harwell research center in Britain. At the left of Kurchatov is Nikita Khrushchev; Nikolai Bulganin is at the right.



My former colleagues are not eager to share their medals with the "great spies."

insistence that the technical materials—the trophies of Soviet espionage—not be published may be considered low-key recognition of the role the intelligence community played at the time. And, as if proposing a conciliatory conclusion, the deputy chief of the Russian Foreign Intelligence Service, Gen. Vadim Kirpichenko, recently suggested: "Let's agree on a hard-fought tie."

But my colleagues in the nuclear weapons establishment are unlikely to find that statement acceptable. After all, the two teams were featured in different weight categories—if not in different leagues. I can find no hint that they are eager to share a part of their outstanding collection of medals with the "great spies." (Fortunately, there is no need to try to redivide the many devalued rubles they were awarded in the Stalin and Lenin prizes.)

I was also amazed at the strong feeling of pride Kharitov expressed at the recent celebration of Kurchatov's ninetieth birthday—a pride of a mission accomplished. "Our country . . . was able to defend itself from really threatening mortal danger," he said. Unfortunately, the bombs could not save the Soviet Union from its eventual chain reaction of self-disintegration.

Finally, on a more prosaic note: the episode inflicted considerable financial damage on *Issues in the History and Methods of Natural*

Science. Many copies of the magazine were at the print shop, ready for shipping when the government decided to veto the publication at the last minute.

In a recent interview in *Poisk* ("Search"), a weekly published by the Russian Academy of Sciences, the editor-in-chief of *Issues in the History and Methods of Natural Science*, said that the editors were misled by the Foreign Intelligence Service about the nature of the technical materials. The service not only told them that the materials were declassified, but that most of the same stories had already been published in a KGB newspaper with an "internal" circulation of 150,000 copies! The interview ends with the editor's complaint: "Who will compensate us for our financial losses?"

Although Russian authorities have prevented early American secrets from being published, the incident raises more troubling questions. Political chaos, lack of discipline, and skyrocketing corruption were already seen as threatening proliferation. This story illustrates how nuclear proliferation might take place in the most unexpected way. The language of the NPT also leaves enough loopholes to justify the export of supporting nuclear technology. In light of the massive geopolitical shifts taking place, as 1995 approaches and the debate begins on the treaty's renewal, the whole question will require another look. ■

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DIVIDING THE GLORY OF THE FATHERS

By SERGEI LESKOV

The door to my office at *Izvestia* opens part way and a quiet, inconspicuous man enters. I look at him with disbelief. Is he really the man I made arrangements to meet? I was expecting an aging James Bond-type with broad shoulders and a proud glance. My guest looked more like a modest clerk from a small office, for whom an occasional beer on the way home and golf on Sundays are big adventures.

However, Col. Vladimir Barkovski of the intelligence services is a real superman. Apparently, in real life, looking inconspicuous is more important than the ability to leap tall buildings. In the 1940s Barkovski was one of the Soviet intelligence agents who obtained many of the West's secrets about the development of nuclear weapons. Today he teaches at the Supreme School for Intelligence Work, researches the history of the Soviet intelligence services, and holds a Ph.D. He visited *Izvestia*'s office after the paper published Academician Yuli Khariton's memoirs on the history of Soviet atomic weapons. In his briefcase Barkovski had documents that had never been published before.

Roald Sagdeev (page 32) is right when he says that an intense debate between the secret service and nuclear scientists is raging in the Russian press. But Sagdeev argues that the foreign intelligence service has begun publicizing its role in the development of Soviet weapons in order to diminish the reputation of

the scientific intelligentsia, which, he says, has been an engine of democratic change. Sagdeev points out that the KGB's role has also been stressed by the ultra-patriotic press, which is close to the anti-Semitic *Pamyat* organization, which would like to downplay the accomplishments of the scientists because many of them were Jewish.

However, it would be an exaggeration to suggest cooperation between the KGB and *Pamyat*. *Pamyat* has carefully calculated that the secret services had a higher percentage of Jews than any other organization. Such a link also seems unlikely now that the foreign intelligence service has been removed from the sadly renowned KGB and put under the direct command of the Russian president. In any case, the secret service has a serious public relations problem: in the minds of Russians, no matter how successful the work of Soviet intelligence may have been on foreign territories, it was never enough to justify the terror that the national security apparatus perpetrated on their compatriots at home.

A painful review of history is taking place in Russia. Everyone, whatever his political orientation, is trying to make a significant place for himself in the chronicles of Russian history. Similar skirmishes are arising around many formerly secret Russian activities. The intensity of these struggles is all the greater because, given the current economic disintegration in Russia, no great new feats are being performed. The heirs of history have no choice but to divide what was achieved by previous generations. The sons now divide the glory of their fathers.

Everyone is busily trying to make a place for himself in history.

Sergei Leskov, who covers science and economic issues for Izvestia in Moscow, is a Bulletin visiting fellow.

**Barkovski says
at least ten
British experts
were supplying
the Soviet
Union with
information
about the
atomic bomb.**

Participants in the nuclear dispute have also suffered from the decline. Nuclear scientists threaten that there will be a brain drain to Third World countries; and it is no secret that the foreign intelligence service is closing a number of its foreign bureaus.

The dispute over the history of nuclear weapons will not be settled any time soon. There are many reasons—including the failure, noted by Sagdeev, to publish secret documents in a historical journal. Both sides saw the documents in question, and not only did they not reach the same conclusions regarding the historical record, they drifted farther apart. Perhaps the reason for the ban on publishing the intelligence record on the bomb program in *Issues in the History and Methods of Natural Science* is part of the struggle for a place on the Mount Olympus of history rather than a concern with nuclear nonproliferation. Experts who saw the banned text told me that even Edward Teller and Andrei Sakharov would not have been able to build a bomb based on the information it contained.

Furthermore, as is always the case in Russia, decisions are carried out only half-way. Such was the case with the circulation of the journal scheduled to publish the documents. Notice of the ban arrived a little late, and at least 200–300 copies got into subscribers' hands. In St. Petersburg, where most of these issues were distributed, it is available to anyone who wants to read it. If Saddam Hussein or Kim Il Sung really think that this half-century-old information could be of any use to them, they will certainly get it despite all the efforts of Russian censors.

Some members of the staff of the magazine maintain that there are other reasons for the ban. Apparently Igor Kurchatov made notes on intelligence reports indicating which pages could be shown to Khariton. For Khariton, "the Last of the Mohicans," the publication of these remarks would mean a blow to his reputation—his role, and the role of the institute in the creation of atomic weapons would be considered less significant.

This is not said to impugn the reliability of the facts Khariton presents. But there are two sides to the controversy. I do not want to take sides, but I have gathered materials on the role of the intelligence service in the creation of the Soviet atomic bomb from a variety of sources. The information that Colonel Barkovski, once known as agent "Dan," made available to me, should be a part of the record.

In 1940, the head of the Science and Technology Intelligence Department, Leonid Kvasnikov (attention, pseudo-patriots: he was also

Jewish), directed a number of foreign bureaus to penetrate Western nuclear research centers to procure information on the work of atomic physicists; this initiative was entirely his own. In 1941 the London bureau obtained the first reliable document on the problems of atomic weapons—a copy of a secret report given to British Prime Minister Winston Churchill. The report contained a detailed account of research in this area.

It is interesting how the opinions of Russian scientists changed after they learned of this report. In December 1941, when Georgi Flerov wrote his first letter urging the Soviet Union to establish an atomic program, a seminar on the possibility of creating atomic weapons was organized. Abram Ioffe, Peter Kapitza, Nikolai Semionov, Nikolai Khlopin, and other important scientists were present. One of the seminar participants, Isaak Gurevich, said later that he was not sure what the result would have been if a vote had been taken to begin work on an atomic bomb.

From 1945 to 1954, the United States conducted a number of atomic bomb tests. Soviet intelligence agents in the United States and England obtained several thousand pages of technical information. Among these documents were calculations for the construction of the plutonium charge; the method of calculating the critical mass of the fissile material; information on the detonation device for the plutonium charge of the atomic bomb; detailed information about the gaseous diffusion factory that produced uranium 235, including a drawing of a section of the cascade assembly of separation units; information about a plutonium production reactor; a report on the study of secondary neutrons and the coefficient of multiplication of neutrons in the mass of pure metallurgical uranium; a series of reports on the metallurgy of uranium and plutonium; and information about the kinetics of atomic reactions. Agents also obtained information about the behavior of less critical systems, about materials used in missile building—beryllium, zirconium, stainless steel—and others, and about methods of preparing uranium rods in protective shells. They also got a complete description of the technique for extracting uranium from pitchblende.

Such extensive information could not have come from Klaus Fuchs alone. According to Barkovski, there were at least ten British experts supplying the Soviet Union with information on the atomic bomb. Some of them, whose identities remain secret, are still alive. Perhaps it was characteristic of the time that they all worked without a financial reward. One of the British spies, when he refused financial compensation, told Barkovski, "You have the Stalingrad battle going on right now;

you need money for tanks." The scientists' first real opportunity to apply intelligence information came with the construction of the first experimental reactor in the Soviet Union, which was begun in Laboratory No. 2 in 1946. Intelligence had also provided a description, measurements, and other information about a heavy-water reactor in April 1945.

Meanwhile, the intelligence service continued its work, even after the Soviet Union developed its own atomic bomb. In the 1950s, for example, intelligence procured information about American power and submarine reactors.

In the old days, when it was not a matter of dividing the glory and fighting each other for a place in the sun, scientists made more positive statements about the contribution of intelligence work in the creation of the atomic bomb. Abram Ioffe said in a report now in the KGB archives: "The information we received was always precise and, most of the time, complete. Of course access to such a complete source of information reduces the volume of our work by many months, facilitates the choice of direction, and frees us from extended searches. Never have I encountered one false instruction." Boris Nikitin, director of the Radium Institute wrote: "These materials are of great practical interest to us. This information greatly reduces the volume of our research. In many cases it is sufficient to test the information instead of conducting special research."

The archives also contain statements about the contribution of the intelligence service to the creation of the hydrogen bomb. In 1947, Isaak Kikoin, asked to evaluate stolen material, wrote: "Remarks about the super bomb in this document are of great interest." Andrei Sakharov himself thought that Americans started working on the hydrogen bomb first, and that if it were not for them, the Soviet Union would not have addressed the thermonuclear problem when it did.

Nuclear scientists may have been rewarded more generously than the intelligence agents who participated in the program. But it is pointless to search for any kind of logic in the hierarchy of Soviet rewards—some irrational principle ruled this sphere. After all, it is ridiculous to think that Leonid Brezhnev deserved his five stars for service to the country. At the same time, one of the most outstanding of Soviet secret agents, Richard Zorge—who warned Stalin about Germany's aggression—was recognized 30 years later only because, by chance, someone pointed out the agent's grave to Khrushchev while he was visiting Japan. Soviet intelligence agents in the Soviet Union were always rewarded modestly in compar-



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son to those in other fields. Fuchs was not rewarded because he had confessed to espionage, violating the immutable principle of the Soviet agent "to keep your silence to the end."

The dispute between scientists and foreign intelligence continues. There was a time when these adversaries used to work together, without consideration for their own lives, on the problem of national security. And no one thought to quantify the merits of other's services. It would be as ridiculous as an argument about which wheel is more important to the car.

This senseless debate is one more expression of a general tendency in today's Russia. As collapse and disintegration embrace all aspects of life, the adversaries who fight for false sovereignty are making a hole in the common ship. The dispute about who deserves the most credit in the creation of atomic weapons has run parallel to the geopolitical and economic problems of the former Soviet Union. And prospects for a quick return of wisdom to the Russian house are foggy. ■

Klaus Fuchs violated the immutable principle of the Soviet agent "to keep your silence to the end."

Permit me to put the question starkly. Although there is ample evidence that nuclear pollution presents health risks, how can we properly assess the degree of risk when the governments that have unleashed the poisons also sponsor virtually all the health research concerning nuclear radiation?

That conflict-of-interest problem has a common-sense solution. We—and “we” refers mainly to individuals and nongovernmental organizations—must insist that independent “watchdog authorities” be established to monitor the work of those who may have a vested interest in underestimating the health risks that may be attributed to nuclear radiation.

These watchdog authorities will not be responsible for conducting the actual health-risk studies. Rather, they will be charged with insuring that the raw data used in health-risk studies are obtained and maintained as objectively as possible.

It's a common-sense idea. But like many simple ideas, it will be a tough sell.

Valid conclusions about the health consequences of various pollutants rest upon databases that can be trusted. If a database is false—either from careless work or from intentional bias—it will cause innocent analysts of the data to fill medical journals and textbooks with misinformation. As surely as a skewed foundation compromises the building erected upon it, a false database turns all users into purveyors of possibly deadly information, no matter how honest they may be. The accuracy of a database is the key to every conclusion that emerges from it. The health consequences of false databases can vary from trivial to tragic.

John W. Gofman, M.D., is a professor emeritus of molecular and cell biology at the University of California at Berkeley. He is the author of Radiation and Chernobyl: This Generation and Beyond (forthcoming).

BEWARE THE DATA DIDDLERS

By JOHN W. GOFMAN

**Without a
watchdog authority,
the same crowd
will continue to play
the same games
with radiation databases.**

Although the principles discussed on these pages focus on radiation research, they apply with equal vigor to databases on dioxins, pesticides, mercury, and other major non-nuclear pollutants.

Because it seems just a matter of common sense to have independent watchdog authorities, many people simply assume that they already exist. But they do not. Not for radiation research, and not for any other pollutant. The current situation regarding databases is unacceptable. Indeed, future generations might characterize it as criminally negligent.

The proposal

The Chernobyl database is already under construction by the International

Program on the Health Effects of the Chernobyl Accident (IPHECA), which will operate through the World Health Organization. The main sponsors of the IPHECA study—with \$200 million suggested for its initial stages—are the governments of the United States, Britain, Russia, France, Germany, and Japan. These governments also sponsor nuclear programs—either nuclear power, nuclear weapons, or both.

The conflict of interest is self-evident, and it is not limited to IPHECA's Chernobyl study. Nearly all radiation research is sponsored by governments

that fiercely defend and promote nuclear energy. I believe that they recognize their goals are not aided if the public comes to believe that radiation is harmful—even at low doses, and even if slowly delivered.

The current situation in radiation research is a bit like relying on the tobacco industry to conduct all the research on the health effects of smoking. Fortunately, we don't do that. Since the 1950s, thousands of independent studies regarding the impact of smoking on health have been organized. In effect, the scientists who have conducted these tobacco studies have acted as watchdogs vis-a-vis the tobacco industry, which takes a generally benign stance toward the products it produces.

Similarly, scientists with the mandate and the financial wherewithal to act independently must “watchdog” the building of radiation databases. I propose that we start with Chernobyl:

■ IPHECA should fund a team of independent scientists who will work inside the Chernobyl study. They would have the authority to make sure that the essential rules of research—as detailed on page 42—are observed. They also would have the right to publish their own views as an integral part of every IPHECA document.

Their assignment would not be to dictate a uniform analysis of the data.

Rather, it would be to insure that the database itself can be trusted and that dissenting views about its handling and its meaning are not punished or silenced.

■ The watchdog scientists will in no way be answerable to governmental authorities. Rather, they would represent the public's right to a "second opinion" on matters of radiation and human health. An independent watchdog supervisory group could be appointed by environmental and other citizen groups to select and oversee the actual watchdog efforts.

■ Watchdog authorities must be permanent. Although the work that goes into the preparation of databases is most intense in the early phases, input is necessarily added for many decades, as the health of participants is followed up. Watchdog authorities must operate for the entire duration

of a given study, because massive violations of the rules can occur even late in a study. (See "Violating the Rules of Research, page 43.)

Un-knowledge

During a lifetime in biomedical research, I've concluded that it is hard to prove anything about anything. There are sampling errors, confounding variables, and necessary equipment that has not yet been invented. The path to understanding is only darkly lit, and the stones strewn along the way are numerous.

Acquiring truth about health and biology is difficult at best. In contrast, acquiring falsehoods about health and biology seems to be inordinately easy. Consider the legions of peer-reviewed professional journals that have carried "evidence" favoring various phar-

maceutical, dietary, surgical, or physical therapies for almost every problem—and the number of disappointments when the initial glowing reports are undermined by later reports suggesting no health benefits at all.

I call such information "biomedical un-knowledge"—shorthand for all the findings that are the opposite of what is true about health and disease.

When I was younger, I assumed that no one wanted "un-knowledge." I no longer make that assumption. Consider the "wish-list" that nuclear energy-promoting governments seem to have for the radiation research they sponsor. It goes something like this:

■ Best of all would be a finding that a little extra radiation improves human health, a sort of invisible Vitamin E. This speculation has a name: hormesis. Indeed, some of its most avid proponents are already writing about the need to treat society in general for "radiation-deficiency disease." The second international conference on radiation hormesis—with some 250 speakers and participants—was held in Kyoto, Japan, last July.

■ The next best finding would be to determine that there was a threshold dose below which no harm occurs. The "safe dose—no risk" claim has become exceedingly common after the Chernobyl accident. For example, the U.S. Energy Department, in its 1987 report on the probable health consequences of Chernobyl, assigned a "zero risk" to some 500 million people exposed to low doses by fallout—if all doses below a half rad are harmless.

In a condensed version of the Energy Department's report (*Science*, December 16, 1988), the assertion that Chernobyl might induce zero extra cancers for persons exposed to low doses was repeated ten times in six pages. That's a fair definition of overkill. There was no mention of the powerful evidence and logic that argue against the threshold speculation.

■ If hormesis and thresholds are not successfully sold to the general public, the next best finding would be to claim—as is often done—that a dose of radiation is far less harmful if it is received slowly over time than if the same dose is received all at once.



April 1990: Children from a collective farm near Chernobyl were hospitalized with radiation-related intestinal problems. AP/WIDE WORLD

As a scientist, I have always taken these wishes and speculations seriously. I have spent years testing them with the existing evidence and with logic. I, too, would prefer for radiation to be harmless. Who would not?

Unfortunately, evidence and logic do not support the wish list. On the contrary, evidence and logic suggest

that low-dose ionizing radiation may well be the most important single cause of cancer, birth defects, and genetic disorders.

Follow the rules

My work on the risks of low-dose radiation has been controversial. Some

scientists say they agree with me. Many say they do not. But whether I'm right or wrong about the low-dose question is irrelevant in evaluating the watchdog proposal. The watchdog idea serves the interests of objective, scientific inquiry. It does not promote the interest of any particular point of view regarding the

The rules of research

There are nine fundamental rules of research that any organization studying the effects of radiation on human health should be required to follow. They may seem unexceptionable, yet they have often been ignored:

■ **Groups must be comparable.** An essential condition for discovering the effects of radiation is reasonable certainty that exposed and non-exposed groups are so similar that the sole reason the groups might be expected to experience different rates of disease and disorder is their exposure to radiation.

■ **The groups must have experienced an actual difference in dose.** If the rate of disease in two groups is being compared, it is essential to establish with reasonable certainty that the groups actually received appreciably different accumulated doses. If, in fact, the groups received nearly the same total amounts of radiation, a study is predestined to find no provable difference in disease rates between the two groups.

■ **The difference in dose must be sufficiently large.** The dose-differences between compared groups must be large enough to allow for statistically conclusive findings despite the random variations in numbers and in population samples. Analysts can cope with the random fluctuations of small numbers both by assuring sufficiently large dose-differences between compared groups, and by assuring large numbers of people in each group.

■ **The dose must be carefully reconstructed.** Obviously, analysts will reach false conclusions if supposedly non-exposed individuals in a database actually received appreciable doses, and if people exposed to supposedly high doses received lower doses than the database indicates. When it comes to Chernobyl, weather patterns caused a very considerable variation in the spread of contamination, which makes this scientific pitfall a real possibility unless careful and objective dose-reconstruction is substituted for assumption. Fortunately, there are several dosimetry techniques that can reduce uncertainty about dose, even decades after the event.

■ **Dose analysts must be rendered demonstrably objective.** Analysts who estimate the dose subjects have received should have no idea of the medical status of the individual or the group to which the individual belongs. Health-status data and dose-related data must never appear in the same file. Analysts must do their work "blind" to protect the database from accidental or intentional bias concerning the relationship between

radiation dose and health.

■ **Diagnostic analysts' objectivity must be confirmed.**

To be credible, studies must be designed to guard against bias at every point. If any study of the effects of Chernobyl is to be valid, this principle must extend to all analysts, physicians, and technicians who diagnose the health status of study participants. They must not know whether an individual's radiation dose was high or low, and they must be denied information (such as place of residence) that would allow them to form an opinion about a likely dose. It is crucial that teams of "special experts" not be allowed to alter diagnoses at a later date—"unblinded."

■ **No retroactive changes in input data must be permitted after any results are known.** In a continuing study, one must not be allowed to alter, delete, or add retroactively to the original input when response results become available. Deciding to revise original data creates an opportunity to falsify the cause-effect relationships (if any) between dose and response. Any study is suspect if retroactive changes are made in diagnosis or dose, if cases are shuffled from group to group, or if any data or cases are suddenly dropped or new cases are added "as needed" from some reserve.

■ **Data should not be excessively subdivided.** Even the largest databases can be rendered inconclusive and misleading if analysts subdivide the data into too many categories or subsets. If analysts hope that a study will find no provable effects even if such effects exist, the outcome can be arranged by creating a "small-numbers problem," which will prevent all or nearly all of the study's results from meeting any test of statistical significance. Moreover, excessive subdivision increases the frequency of finding random effects, which may pass the test of statistical significance, but which are nevertheless false. Selective preservation of such false findings can be used to support an intentional bias. Any excessive subdivision of data should be viewed with suspicion.

■ **No pre-judgments are permitted.** Both pre-judgments and hypotheses are ideas held at the outset of an inquiry. Pre-judgments are assumptions, often unstated, that can cause investigators to ignore or discard particular evidence. In contrast, hypotheses are tentative explanations, openly stated, that invite challenges from other investigators.

—J. G.

Violating the rules of research

The atomic bomb survivors database is updated and managed by the Radiation Effects Research Foundation (RERF) in Hiroshima. RERF is sponsored by the U.S. Energy Department and the Japanese Ministry of Health. In 1986, RERF virtually replaced the existing database, which had been used for about 21 years. New doses were assigned to survivors, many of the study's participants were suspended, and the remaining participants were shuffled into new groupings (cohorts). The reason given for these retroactive alterations was a set of revised dose estimates for both neutrons and gamma rays, from the 1987 publication, *U.S.-Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry in Hiroshima and Nagasaki: Final Report*.

This revision is a violation of a basic research rule—that no retroactive changes in input data are permitted after any results are known. Parallel analysis with both old and new dose estimates, without an assault on the cohort structure of an ongoing study, is an acceptable practice to take account of new dose estimates, but RERF did not use it. Instead, its maneuvers with the A-bomb study database create a potential to revise the results to fit a preferred outcome. In contrast, credible epidemiological research makes elaborate efforts to avoid this possibility.

I complained about the rule violation to Dr. Itsuo Shigematsu, the RERF chairman. In a letter to me, he replied in part: "Concern about bias does not appear to be justified. We shall, however, be sure to consider the necessity, and if so, the feasibility of dual analyses of our data [altered and non-altered input]."

RERF is already revising its revised database, which is called "the basis for any future amendments to the A-bomb survivor dosimetry that may be desirable." Perpetual, retroactive alteration seems to be RERF policy.

Meanwhile, RERF provided me with the old "unshuffled" data (the original database) as well as its new "shuffled" data through 1985 for an independent examination. (This examination is described in the fourth chapter of *Radiation and Chernobyl, This Generation and Beyond*, forthcoming.) For radiation-induced cancer, rates were calculated using both old and new dose estimates with the unshuffled cohorts. Both analyses show that low-dose radiation is more harmful per dose-unit than high doses of radiation. By contrast, other analysts using only the new dose estimates with a shuffled cohort, have published a curve suggesting that low dose radiation is less carcinogenic per dose-unit than high-dose radiation.

Similar results were found when the database was shuffled and instances of radiation-induced mental retardation were examined. Serious mental impairment occurs when an eight to 26-week-old fetus receives an appreciable dose of radiation. The unaltered database

suggests that there is no "safe" dose or threshold. But RERF analysts have frequently suggested that the atomic bomb survivor study indicates a possible threshold. Almost all the difference in interpretation can be explained by RERF's choice of the retroactively altered database; key cases of mental retardation have been moved from one dose category to another.

The retroactively altered database produces data on cancer and mental retardation rates that are more favorable to nuclear polluters than the unaltered database. Database "shufflers" should be required to demonstrate that no bias was introduced by their research rule violations, particularly because their sponsors are not neutral observers. In a matter of such importance to human health, these rule violations should not be tolerated at all.

Different rules of research have already been broken in the study of Chernobyl health effects. By 1989, three years after the Chernobyl accident, a number of complaints about health problems in Belarus and Ukraine had reached the press. At the request of the Soviet government, the International Atomic Energy Agency (IAEA) organized a study, led by Dr. Shigematsu. In May 1991, Shigematsu announced that the IAEA's international experts had found no relationship between illnesses in Belarus and Ukraine and the release of radiation from Chernobyl.

The IAEA study received a great deal of attention in the public press, but it was sharply criticized in scientific journals—as it should have been. It was flawed in a number of ways. The study broke more than one of the rules.

IAEA teams sampled seven "contaminated" and six "uncontaminated" or "control group" villages. The researchers then selected a radiation-exposed population that had received doses that may have been less than one rem higher than the doses of those in the control group—if they were any higher at all. Under such conditions, the search for meaningful results was doomed from the beginning, and the IAEA's conclusion was predictable from the start. The IAEA did not compare effects in "control" villages with villages where far higher doses were received (in many of the villages that were not included in the study, doses exceeded 20 rem).

If only small differences in dose are examined, careful dose reconstruction is critical. But the IAEA researchers did not do this adequately. For several days, the Chernobyl 4 reactor burned graphite, and short-lived and intensely radioactive nuclides were released, which made later estimates of exposure based only on levels of cesium 137 unreliable. Using cesium 137 levels rather than careful measurements of actual biological doses contributed to inherently questionable conclusions.

—J. G.

possible outcomes of specific studies.

It is fortunate that we do not often have disasters of the magnitude of Chernobyl. But the tragedy of Chernobyl will be compounded many-fold if we squander the opportunity to learn everything possible about the health risks associated with it, as well as its ecological consequences.

Creating a trustworthy database from an event such as the Chernobyl accident is a profound obligation of the world's scientific community. If research on the radiation consequences of Chernobyl is poorly designed or biased, or both, the false conclusions will nevertheless enter the professional literature and the textbooks.

Research that exaggerates the health hazard of radiation will be a disservice to humanity. But if researchers *underestimate* the true health hazards, the misinformation will be literally deadly, because it will result in great increases in "permissible doses" and unnecessary and preventable human exposures to radiation in the environment, in occupations, and in medical treatment.

To help prevent the production of false databases and false "findings," either through bias or scientific error, medical science has developed the already noted rules of research. These rules are acknowledged implicitly or explicitly throughout the epidemiological literature.

The key to creditable and credible research in the health effects of radiation is full obedience to these rules. Strict adherence to the rules simply eliminates issues regarding conflict of interest and scientific misconduct. No one needs to raise such issues—if impeccable adherence to the basic rules can be demonstrated. But whenever such adherence cannot be demonstrated, society would be ill-advised to accept the purported scientific "findings."

These assertions are not intended to impugn the motives or the work of most scientists who prepare or analyze radiation databases, although some misconduct exists in every field. But as already noted, if the rules of research are violated in building databases, no analyses of the data can escape the poison. The first obligation of every objective scientist is to question the believ-

ability of raw data before he or she uses them.

Everyone wins

Perhaps IPHECA itself should have thought about introducing the watchdog concept, as a means of obtaining credibility for its studies. However, IPHECA has not done so.

Although I don't expect IPHECA's scientists to endorse the watchdog concept publicly, I suspect that most of them will privately welcome it. Most scientists, after all, would prefer to be honest and to do impeccable work.

Under a watchdog authority, everyone wins. The scientists win by being liberated from humiliating pressures to please their employers. The victims of nuclear accidents win

It's up to us. Government sponsors of nuclear power and nuclear weapons will never propose an independent watchdog authority.

by having objective, reality-based evaluations of the harm or lack of harm they have been exposed to. And of greatest importance, humanity gains by being freed of the specter of 100 years of biomedical un-knowledge about the health effects of radiation.

The watchdog proposal establishes a system that rewards and honors truth-telling, instead of punishing it by loss of employment. Further, the watchdog remedy requires no technological breakthroughs to make it feasible.

The only requirement: A firm insistence that it is necessary, an idea whose time has truly come. We cannot expect governments to be the source of such insistence. The demand must come from all segments of society, not just scientists. The sooner that people create a ground swell of support for such a concept, the earlier it will become a reality.

I urgently invite all individuals, groups, and organizations to let me know if they will permit themselves

to be included on a list of endorsers of the watchdog concept.

Last December, the concept received emphatic support from the international jury of the Right Livelihood Award Foundation in Stockholm. Subsequently, I have received very favorable reactions to the proposal from a variety of scientific, environmental, and political figures in Ukraine, Belarus, and Russia.

The dollar costs of watchdog authorities over the decades will not be trivial, per database. But the work of the watchdogs is at least as important to ordinary taxpayers as is the work of the governmentally sponsored teams underwritten by their taxes. I suggest that funding for independent watchdog authorities should come from the same budget that supports governmentally funded investigators. For the sake of discussion, I suggest five percent of the budget.

For the Chernobyl database, if the initial budget for IPHECA is \$200 million, five percent would be \$10 million. If five percent of IPHECA's budget (whatever its ultimate size) is transferred to an independent watchdog authority, I suspect that taxpayers—or at least those who were aware of it—would rejoice.

Why are the nuclear-committed governments so ready to conduct health studies concerning Chernobyl? And Chelyabinsk? And why do they continue to govern the studies of Hiroshima and Nagasaki?

They claim, of course, that they conduct such studies for the sake of truth, and for the benefit of all humanity. But at the grassroots, ordinary people may judge the sincerity of such claims by how positively governments respond to the watchdog proposal. Making the proposal is relatively easy, of course. The hard part will be building a critical mass of international support to make it a reality.

The sponsors of current research on radiation and other types of pollution may fight vigorously behind the scenes to kill the watchdog idea. And after the watchdog proposal is accepted—soon, I hope—people must still remain vigilant. They must insure that independent experts are not—or do not become—sheep who wear a watchdog costume. In the end, we are all watchdogs. We owe future generations at least that much. ■

Reducing R&D

Dismantling the Cold War Economy
by Ann Markusen and Joel Yudkin
Basic Books, 1992
314 pages, \$25.00

DAVID GOLD

The initial euphoria over a possible peace dividend has been replaced by end-of-the-Cold-War economic realities that include political jockeying over the future of weapons systems, a paucity of meaningful conversion efforts, and the suspicion that a weak economy will not be able to compensate for the loss of jobs and purchasing power as defense budgets are reduced.

In *Dismantling the Cold War Economy*, Ann Markusen and Joel Yudkin explore why peace dividends are illusory, and transforming swords into ploughshares is difficult. The authors discuss three interrelated hypotheses. The first is that the existence of a large military production sector has depleted the civilian economy of key resources and preempted creation of the kind of broad-based civilian-oriented industrial policies needed for economic revitalization.

The second is that a large military production sector creates barriers to the movement of resources, and the third is that economic depletion and the barriers to moving resources to civilian production make conversion planning essential. Markusen and Yudkin do an admirable job of describing these theses.

But is it accurate to argue that military production is a major cause of current U.S. economic weakness? It would be hard to tell (from reading this book, for instance) that the military economy is half the size it was three decades ago, relative to the economy as a whole. From 1956 through 1960, after the Korean War build-up (and subsequent build-down), the military complex accounted for 12 percent of gross national product (GNP). Three decades later, in 1986-1990, the military accounted for slightly over six percent of GNP. It could be said that the United States has experienced a long-term "peace dividend" of some six percent of GNP.

If—as the authors suggest—military demands were a powerful nega-

tive force on the economy, cutting the defense burden in half should have had a noticeable positive impact on U.S. economic performance. Instead, as is generally accepted, the economy has performed more poorly than in the 1950s. Markusen and Yudkin's arguments (and those presented by Markusen and others in an earlier book, *The Rise of the Gunbelt*), seem to show that defense had a significant and positive economic impact during the period when the defense burden was greatest.

One response to this objection is that economic distortions occur primarily in high technology fields where the military has significant influence. Here, too, the evidence suggests a diminished military impact. In the 1950s and the 1960s, various researchers estimated that between 30 and 50 percent of all scientists and engineers were employed on military-related projects. That portion had declined to about 20 percent by the mid-1980s, according to National Science Foundation surveys, and it is undoubtedly lower today.

Similarly, the national share of research and development devoted to the military declined substantially from the 1950s to the 1980s, despite the R&D component of the Reagan defense buildup. Thus, we have experienced a "high-tech" peace dividend too.

Markusen and Yudkin also argue that the United States has had a "closet industrial policy" in the defense-dominated aerospace-communi-

cations-electronics complex, and that this policy created competitive, world-class industries whose "vitality" was purchased at the price of stagnation in the rest of the industrial base, especially in producer goods." They present no evidence that the U.S. failure to institutionalize a comprehensive industrial policy framework is related to the pre-existence of such a framework within the defense economy; they simply assert such a link.

However, the United States has had extensive government-led "industrial policies" in transportation since the early 1800s, and in agriculture since the Civil War. Even now a massive industrial policy aimed at medical delivery is evolving, with the U.S. government involved in funding research, procurement, and price-setting. Although industrial policy exists in this area, its effectiveness is debatable. The health sector now accounts for 12 percent of GNP, twice as large as the share attributed to defense.

The authors are on stronger ground when they examine the defense sector's insularity and the difficulties involved in moving resources to civilian activities. Their description of the ways in which each labor force segment has been affected by defense spending is particularly good. They regard as especially significant the "wall of separation" between defense and civilian research and development, although that wall is probably



"The changeover from weapons to the manufacture of household appliances is complete. Unfortunately, our toasters are too lethal for household use."

more porous than they suggest.

Markusen and Yudkin believe that overcoming this insularity will require extensive government involvement in conversion. Of course, government policies can help surmount stubborn defense economy barriers; conversion of military activities to civilian ones is similar to moving resources out of other large, declining sectors. But it matters little whether the sectors have been productive or unproductive, expansionary or depletionist. What matters is the redirection of resources to alternative activities.

Markusen and Yudkin devote only a few pages to specific conversion proposals. A comparison of different conversion strategies and policies would have been useful—as would have been a discussion of problems common to defense and non-defense transformations. The book may explain why conversion is difficult, but solutions require a broader focus on the sources of U.S. economic problems than depletion theory advocates have mustered thus far. ■

David Gold, a U.N. economist, is the author of The Impact of Defense

Spending on Investment, Productivity and Economic Growth. *The views expressed are his own.*

PROPAGANDA (cont. from p. 12)

the battlefield, and to return the contaminated parts to South Carolina as nuclear waste. But nothing has been done in Iraq, and little has been done in Kuwait, to recover the remaining depleted-uranium rounds. According to knowledgeable sources involved in the Kuwaiti cleanup effort, workers were unprepared to deal with the hundreds of Iraqi armored vehicles that were contaminated by depleted uranium rounds. The problem remains unresolved.

What is needed is a hard-nosed assessment of the costs and benefits of continuing to use depleted uranium, factoring in all the manufacturing, testing, exposure, and disposal questions, as well as the fact that the U.S. arsenal has a wide variety of capable anti-tank weapons.

In the mid-1980s, the U.S. Navy, concerned about possible exposures to crews, quietly evaluated the downside of using depleted uranium in its

Phalanx gatling gun, a shipboard air-defense weapon. According to the Naval Sea Systems Command history for 1989, released under the Freedom of Information Act, "It was proven that the tungsten penetrator provides improved round effectiveness while eliminating safety and environmental problems associated with depleted uranium." A decision was made to switch to tungsten, and procurement began that year.

Fifteen years ago, when the U.S. military's intention to use uranium bullets first became public, Republican Sen. Robert Dole, now minority leader, denounced the program in the *Congressional Record* as "shocking." Here is something that—in theory—Bob Dole and Ramsay Clark can agree on, yet their political positions are universes apart.

Still, the desert is not glowing, unless one considers the glow of the propaganda machine that continues to benefit from yet another nuclear waste. ■

William M. Arkin is director of military research for Greenpeace International and a Bulletin contributing editor. He spent the month of February in Iraq.

"In school they showed a film called 'A is for Atom, B is for Bomb.' Most of us who grew up in that period added 'C is for Cancer, D is for Death.'"
— Jay Truman, Salt Lake City, Utah, 1987

AMERICAN GROUND ZERO THE SECRET NUCLEAR WAR



CAROLE GALLAGHER

AMERICAN GROUND ZERO The Secret Nuclear War

Carole Gallagher

foreword by Keith Schneider

"This is more than a cautionary tale. It is a revelation of something apocalyptic. The Soviet Union was condemned by the world for keeping Chernobyl a 3-day secret. Our nuclear bomb tests in Nevada were kept a 30-year secret. Our respected scientists, engineers, and administrations were the guilty parties and we, the American people, were kept wholly ignorant of peril without precedent. It's a lalapalooza of a book." — Studs Terkel

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False alarm

As a community member of the Working Group to Address Los Alamos Community Health Concerns, I would like to comment on the "In Brief" item in the March *Bulletin* that described responses to a local artist who claimed that he had found a cluster of brain tumor cases in a Los Alamos, New Mexico, neighborhood.

The situation has been thoroughly investigated. A study by the New Mexico Department of Health and the New Mexico Tumor Registry found only 22 occurrences of brain tumors in Los Alamos, and only three in the neighborhood in question, rather than the 80 or so claimed by Tyler Mercier. An independent analysis of soil in the neighborhood also showed nothing alarming. Numerous studies of other possible hazards have failed to disclose anything unusual.

During the two years that this issue has been investigated, many people with a great personal investment in one or the other position have listened sincerely to one another and judged the data impartially, even data damaging to their cause.

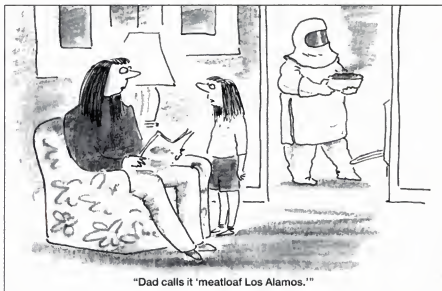
Anger at having been upset by a false alarm may account for some of the unseemly remarks made about Mr. Mercier. Any public debate provides extremists with a forum for making a display of themselves.

Helen Stanbro
Los Alamos, New Mexico

Hawks in sheep's clothing

We at Operation Real Security have often turned to your journal in the past as we helped lead the grassroots fight against unnecessary military spending and the Gulf War. But why should I underwrite John Isaacs's paean to George Bush as a peace leader and Jane Sharp's call for military intervention in the Balkans? (March 1993 *Bulletin*). I might as well donate to the Heritage Foundation.

Both authors have made major contributions to the peace movement in the past, but their view of the "new world order" is troubling. Isaacs's eulogy to George Bush as a disarmament leader is ludicrous. Given that the



enemy quit and sued for peace five years ago, a real leader could have already brought nuclear weapons down at least to the 500 suggested by Freeze leaders during the Cold War. Dan Ellsberg argues persuasively that the United States can now eliminate nuclear weapons entirely by the year 2000. By comparison, Isaacs's assessment of Bush's reductions seems like terminal inside-the-beltway-itis.

Isaacs whitewashes Bush's intervention record. Bush not only kidnapped Noriega, he invaded a sovereign nation and killed thousands. And I don't think it will take "history" to sort out the "appropriateness" of Bush's January 1993 bombing of Iraq.

As for Jane Sharp, on at least two occasions she has asserted that the United States would not be a "civilized" nation if it failed to use military force in the Balkans. As a combat veteran of Vietnam, I was especially offended by her willingness to risk somebody else's children as "casualties" to prove we're not "fat and complacent."

As a peace activist, I want a journal that provides analytical support for non-violent approaches to regional peace-making. The United States should not become the world's cop. Indeed, the U.S. military shouldn't go anywhere outside our borders. The United States should pay up its U.N. dues so that a truly international body can take on military missions if advocates of nonviolence are outvoted. The United States should increase the share of GNP going to foreign aid (and direct that aid to foster locally self-reliant development).

Of course, I detest the Serbian atrocities. But my skepticism is rekindled when Croatian excesses are glossed over and there is no analysis of the interests of George Bush's global corporate crowd in the Balkans.

This is a tough time for the peace movement. Many former leaders—not just Isaacs and Sharp—advocate wide-ranging military intervention. They ignore the warnings of Ruth Sivard and Dwight Eisenhower. Every billion dollars spent on the military is still a theft from the poor of the world. An expanded military role inevitably reduces the money for inoculations, food for children, and other aid for the poor, both at home and abroad. People die from those budget decisions as surely as if they were stabbed by the pen used to sign the bills. The same distorted budget priorities force our young people into the military for careers and teach young Ollie Norths how to deceive the media. "Made-for-TV" interventions are the post-Cold War equivalent of the red book the Pentagon used to publish each year to exaggerate the "Soviet threat" just in time to justify its bloated budget requests.

You can't be for and against an oversized military. My former colleagues at MIT, Jerry Wiesner, Philip Morrison, and Kosta Tsipis, know which side they are on when they call for a 60 percent reduction in military spending by 2000 (March 1993). John Isaacs and Jane Sharp used to know. What about the *Bulletin*; which side are you on?

Jim Driscoll
Tempe, Arizona

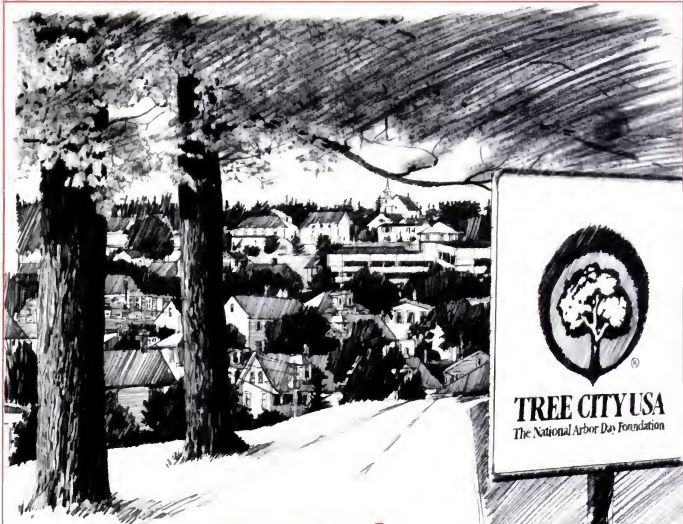
	United States	Soviet Union	Britain	France	China
Warheads					
Warheads in stockpile	10,500 active, 6,000 awaiting disassembly	15,000 active, 18,000 awaiting disassembly	200	540	450
Peak number of warheads/year	32,500/1967	45,000/1986	410/1969	540/1993	450/1993
Total number of warheads built/year	70,000 1945–1992	55,000 1949–1992	915 1952–1992	1,150 1960–1992	600 1964–1992
Number of known test explosions (end of 1992)	942	715	44	210	38
Weapon development milestones					
Atomic bomb developers	J. Robert Oppenheimer, Gen. Leslie Groves	Igor V. Kurchatov	William G. Penney	Gen. Charles Ailleret, Pierre Guillaumat	Nie Rongzhen, Liu Jie, Deng Jiaxian
Hydrogen bomb developers	Stanislaw Ulam, Edward Teller	Andrei Sakharov, Yuli B. Khariton, Yakov B. Zeldovich	William Cook, Keith Roberts, Brian Taylor	Robert Dautray	Deng Jiaxian, Yu Min, Peng Huanwu
First operational ICBM	Oct. 31, 1959 Atlas D	1960 SS-6	none	Aug. 2, 1971 S-2 IRBM	Aug. 1981 Dong Feng-5
First nuclear-powered naval SSN enters service/vessel	Jan. 1955 <i>Nautilus</i>	Aug. 1958 <i>November</i>	1963 <i>Dreadnought</i>	Jan. 1971 <i>Le Redoutable</i>	1974 <i>Han</i>
First SSBN patrol with Polaris-type SLBM/vessel/missile	Nov. 15, 1960 <i>Washington</i> Polaris A1	1968 <i>Yankee</i> SS-N-6	June 1968 <i>Resolution</i> Polaris A3	Jan. 28, 1972 <i>Le Redoutable</i> M1	1986 <i>Xia</i> Julang-1
First MIRVed missile deployed	Aug. 19, 1970 Minuteman III	1974 SS-18 or -19 ?	1994–1995 Trident II	April 1985 M-4A SLBM	none
Testing milestones					
First fission test, type/yield	July 16, 1945 Plutonium/23 kt.	Aug. 29, 1949 Plutonium/20 kt.	Oct. 3, 1952 Plutonium/25 kt.	Feb. 13, 1960 Plutonium/60–70 kt.	Oct. 16, 1964 U-235/20 kt.
First test of boosted fission weapon/yield	May 8, 1951 Item/46 kt.	Aug. 12, 1953 Joe 4/400 kt.	May 15, 1957 ? Short Granite/ 150 kt. ?	Sept. 24, 1966 Rigel/150 kt.	May 9, 1966 ~ 200 kt.
First multistage thermonuclear (hydrogen bomb) test/yield	Oct. 31, 1952 10.4 mt.	Nov. 22, 1955 1.6 mt.	April 28, 1958 2 mt. ?	Aug. 24, 1968 2.6 mt.	June 17, 1967 3 mt.
Number of months, first fission bomb to first multi-stage thermonuclear	87	75	66	102	32

	United States	Soviet Union	Britain	France	China
First airdrop explosion of nuclear weapon/aircraft used	Aug. 6, 1945 B-29	Nov. 6, 1955 Bear ?	Oct. 11, 1956 Valiant	July 19, 1966 Mirage IV-A	May 14, 1965 Hong 6
Known atmospheric tests (includes underwater)	217	214	21	50	23
Largest atmospheric test	Feb. 28, 1954 15 mt.	Oct. 30, 1961 50 mt.	Sept. 1958 2.5-3 mt.	Aug. 24, 1968 2.6 mt.	Nov. 17, 1976 4 mt.
Last atmospheric test	Nov. 4, 1962	Dec. 25, 1962	Sept. 23, 1958	Sept. 15, 1974	Oct. 16, 1980
First underground test	July 26, 1957	Oct. 11, 1961	March 1, 1962	Nov. 7, 1961	Sept. 23, 1969
Largest underground test	Nov. 6, 1971 5 mt.	Oct. 27, 1973 2.8-4 mt.	Dec. 5, 1985 <150 kt.	July 25, 1979 120 kt.	May 21, 1992 660 kt.
Current test sites	Nevada	Semipalatinsk*, Novaya Zemlya	Nevada	Monuroa atoll, Fangataufa	Lop Nur (Malan)

The nuclear infrastructure

Assembly and disassembly plants	Pantex near Amarillo, Texas	Nizhnyaya Tura (Sverdlovsk-45), Yuryuzan (Zlatoust-36), Penza (Penza-19)	Burghfield Royal Ordnance near Reading	Centre d' Etudes de Valduc (Côte-d'Or)	Subei (Gansu), Guangyuan (Sichuan)
Plutonium production/ number of reactors	Hanford*/9 Savannah River*/5	Chelyabinsk-65*/6 Tomsk-7/5 Krasnoyarsk-26/3	Calder Hall/4 Chapelcross/4 Windscale*/2	Marcoule*/3 Chinon-2*, -3*/2 Bugey-1/1 Phénix/1 Celestin-1, -2/2	Jiuquan (Gansu)/1 Guangyuan (Sichuan)/1
Uranium enrichment plants	Oak Ridge,* Portsmouth, Paducah	Verkni-Neyvinsky, Krasnoyarsk, Angarsk, Tomsk	Capenhurst	Pierrelatte	Lanzhou, Heping (Sichuan)
Chief design labs	Los Alamos, New Mexico; Lawrence Livermore, California	Arzamas-16, Chelyabinsk-70	Aldermaston near Reading	Limell-Valenton in Val-de-Marne	Ninth Academy Mianyang (Sichuan)
Current directors and administrators	Hazel O'Leary, Energy Secretary; Siegfried Hecker, dir., Los Alamos; John Nuckolls, dir., Livermore	Viktor Mikhailov, Minister of Atomic Energy and, dir., Arzamas-16; Evgeni Avrorin, Scientific dir., Chelyabinsk-70	Donald Spiers, Controller of Establishments, Research and Nuclear; Brian Richards, dir., Aldermaston	Roger Baléras, dir., Direction des Applications Militaires	Hu Renyu, dir., Ninth Academy; Hu Side, Deputy dir.

*No longer operational. **"Boosted"**: small quantities of tritium and deuterium incorporated in fission weapon to increase efficiency of yield; **kt.**: kilotons; **mt.**: megatons; **ICBM**: intercontinental ballistic missile; **IRBM**: intermediate-range ballistic missile; **SSN**: nuclear-powered submarine; **SSBN**: nuclear-powered ballistic missile submarine; **SLBM**: submarine-launched ballistic missile.



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